

Water Quality Analysis of the San Pedro Creek Watershed



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CHAPTER I

INTRODUCTION

Justification and Need for the Study

Streams are a critical component of the natural environment. Their importance is typically expressed as functions and beneficial uses. Key functions of streams include moderation of water table, sediment transport, flood storage and conveyance. The San Francisco Bay Regional Water Quality Control Board (1995) identifies specific beneficial uses for streams including municipal and domestic supply, agricultural supply, industrial process supply, groundwater recharge, water contact recreation, wildlife habitat, cold fresh water habitat, fish migration, and fish spawning. Considering the beneficial uses provided by streams, protection of these systems and their watersheds¹ are needed.

The availability of water on Earth is approximately 1.384 billion km³ and just 2.52% (or 35 million km³) is fresh water. Lakes, rivers and groundwater, main sources of water for human use and consumption, contain on average about 90,000 km³ of water (0.26% of the total global fresh water reserves) (Mays 1996). Fortunately, these amounts are continuously collected, purified and distributed in the hydrologic cycle. This natural recycling and purification process provides plenty of fresh water as long as we do not overload it with

¹ A watershed is defined as "...the area, which contributes water to a particular channel or set of channels. It is the "source" area of the precipitation eventually provided to the stream channels by various paths." (Leopold *et al.* 1964).

slowly degradable and non-degradable wastes or withdraw water from surface or underground supplies faster than they can be replenished. Unfortunately, we are doing both, generating, as a consequence, a tremendous disequilibrium in the environment (Margaleff 1996).

Human activities have long influenced rivers in many parts of the world. The effects of human development on streams are well documented and include extensive changes in basin hydrologic regime, channel morphologic features, and physiochemical water quality (May *et al.* 1997). The most obvious manifestations of urban development affecting streams and their surrounding watersheds are an increase in impervious cover and the corresponding loss of natural vegetation, land clearing, soil compaction, riparian corridor encroachment, change in water quality and aquatic communities, and modifications to the surface water drainage network (Fisher and Grimm 1996, Margaleff 1996 and May *et al.* 1997).

Research Area and Objectives

San Pedro Creek is an urban, coastal, perennial stream located in Pacifica, California approximately 15 miles south of San Francisco (Figure 1). The creek drains a 5,114 acre basin (8 square miles) and is composed of five main tributaries that define several subwatersheds. Table 1 and Figure 2 (p. 8) show major and minor subwatersheds:

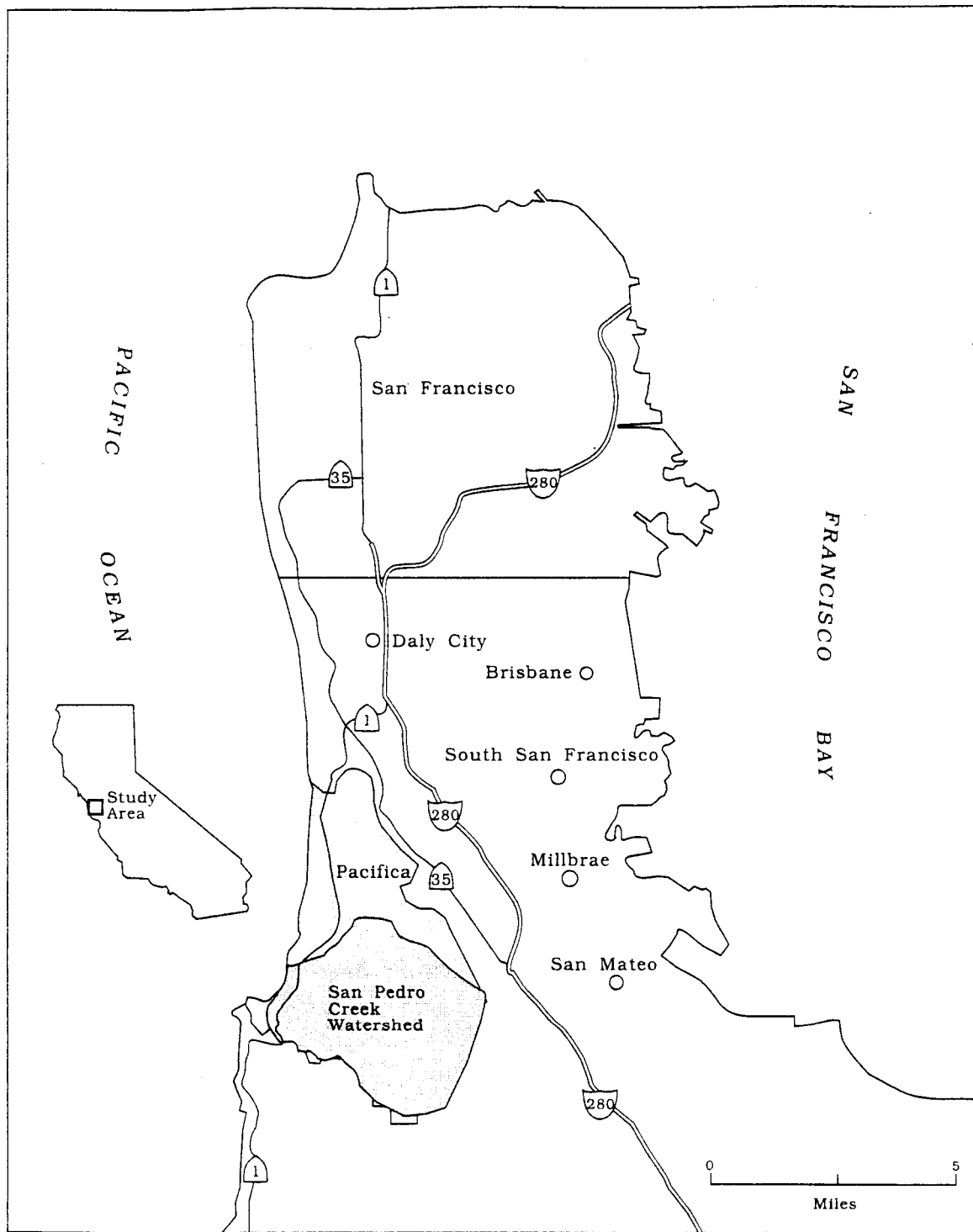


Figure 1. Area of Study. San Pedro Creek Watershed, Pacifica, California

Table 1. Major and minor subwatershed in San Pedro Creek Watershed

Subwatershed	Area (Hectares/Acres)	Average slope (%)
North Fork	614 ha/ 1517 ac	21.1
Middle Fork	329 ha/ 1543 ac	24.1
South Fork	284 ha/ 703 ac	26.0
Combined Middle and South Fork	624 ha/ 1543 ac	
Sánchez Fork	237 ha/ 582 ac	24.4
Shamrock Fork	146 ha/ 361 ac	18.7
Pedro Point subwatershed	51.4 ha/ 127 ac	22.0
Hinton subwatershed and minor ones	65 ha/ 161 ac	15.1

Source: San Pedro Creek Coalition 1999

The upper reaches of the watershed are formed by the north, middle, and south forks of San Pedro Creek. Stream flows are maintained by springs in the south and middle forks of the basin. After their convergence at the head of the valley floor, the main stem flows northwesterly toward the Pacific Ocean. The San Francisco Bay Regional Water Quality Control Board (1995) identifies six specific beneficial uses for San Pedro Creek including municipal and domestic supply, non-contact water recreation, cold fresh water habitat, fish migration, and fish spawning. Thus, the creek provides a critical habitat for a state and federally threatened species, the steelhead trout (*Oncorhynchus mykiss*), and is the only creek within thirty miles of the San Francisco Peninsula providing this type of habitat (San Pedro Creek Coalition 1999).

Water quality in San Pedro Creek is being affected by land use in the form of residential development. Exploratory testing performed by the

Environmental Protection Agency (EPA) and the City of San Francisco Waste Water Treatment Plant indicate that San Pedro Creek is contaminated. Tests conducted over a two-year period (1996-1998) indicate that coliform, fecal coliform, enterococcus, *Escherichia coli* and streptococcus levels in the North Fork and main stem far exceed both State of California and EPA maximum levels for recreational waters. These levels of bacterial contamination pose a health risk to people living along the creek and to those members of the public using the creek for recreational purposes, and may affect the habitat quality for the steelhead trout and other biotic and abiotic components of the creek. The San Mateo County Health Department has confirmed these findings and posted the lower reach of the Creek as unsafe for human use (San Mateo County Health Department 1998-1999).

In order to protect, enhance and maintain San Pedro Creek Watershed, this research seeks to study the water quality of the stream considering the following objectives: 1) To establish and compare physical, chemical and biological water quality characteristics in San Pedro Creek Watershed during four sampling periods (winter (January-February), late spring (April-May), summer (July-August) and fall (October-November) (seasonal variability), 2) to compare in-stream physical, chemical and biological characteristics of the watershed to the San Francisco Regional Water Quality Control Board, the Environmental Protection Agency (EPA) or literature standards, and 3) to determine whether cumulative changes occur in water quality along the creek (variability over space). The method used in this study is a routine type of

water monitoring involving the periodic collection of samples from a number of fixed locations along the watershed (Bartram and Helmer 1996).

Water quality monitoring is defined as the process of sampling, measuring, recording and analyzing various water quality characteristics (Bartram and Helmer 1996). An important objective of water quality monitoring is to provide managers with appropriate information that aids the decision-making process. Water quality studies are important tools that provide valuable and sufficient information to maintain a high level of stream quality or ecological integrity (physical, chemical and biological) (Eyre and Pepperell 1999).

The results of this research provide important information about the water quality dynamics in the creek. This information will be helpful in identifying sources of pollution and controlling their impact on the watershed and its ecological integrity; providing base-line information for decision-making; restoring, protecting and maintaining activities; establishing a permanent water quality testing program to ensure high water quality; and building a sense of the importance of the creek and its role in the watershed. Furthermore, this research could be used as a model for similar watershed programs that seek to develop a monitoring and protecting program in order to preserve urban creeks and their watersheds.

Organization of the Study

The next chapter describes the area of study. Climate, geomorphology, vegetation and land use are considered. Chapter III reviews literature about water quality, including field studies using similar approaches. The methods used in this study are described in Chapter IV. Results are presented in Chapter V. Chapter VI contains the analyses and discussion of results. The final chapter presents conclusions and recommendations for future research.

CHAPTER II

STUDY AREA

The San Pedro Creek Watershed and Sub-Watersheds

San Pedro Creek watershed has a system of sub-watersheds with somewhat different land uses (Figure 2). The North Fork (614 ha) is the most problematic of the sub-watersheds in that it is culverted on both its northeast (Oddstad) and northwest (Terra Nova) forks. Residential development dominates but two schools, a park and a commercial horse stable occupy a portion of the watershed. A cattle ranch and a park, constructed in 1972 on a landfill, are also located in the upper portion of the sub-basin. As with all of the sub-watersheds, its upland drainage areas are steep and drain rapidly into culverts. Because storm drains convey runoff quickly from impervious surfaces in developed areas, the North Fork sub-watershed responds especially rapidly to rainfall events. Because the lower reaches of this watershed have been extensively developed, the riparian corridor exists only in the uppermost headwaters and in the 300-foot (91.5 meters) section above the confluence with the Middle Fork (San Pedro Creek Watershed Coalition 1999). The mean slope of the North Fork is 21.1 percent (21.1 feet drop in 100feet)(Derived from USGS Montara Mountain 7.5' 10-m Digital Elevation Model 1999).

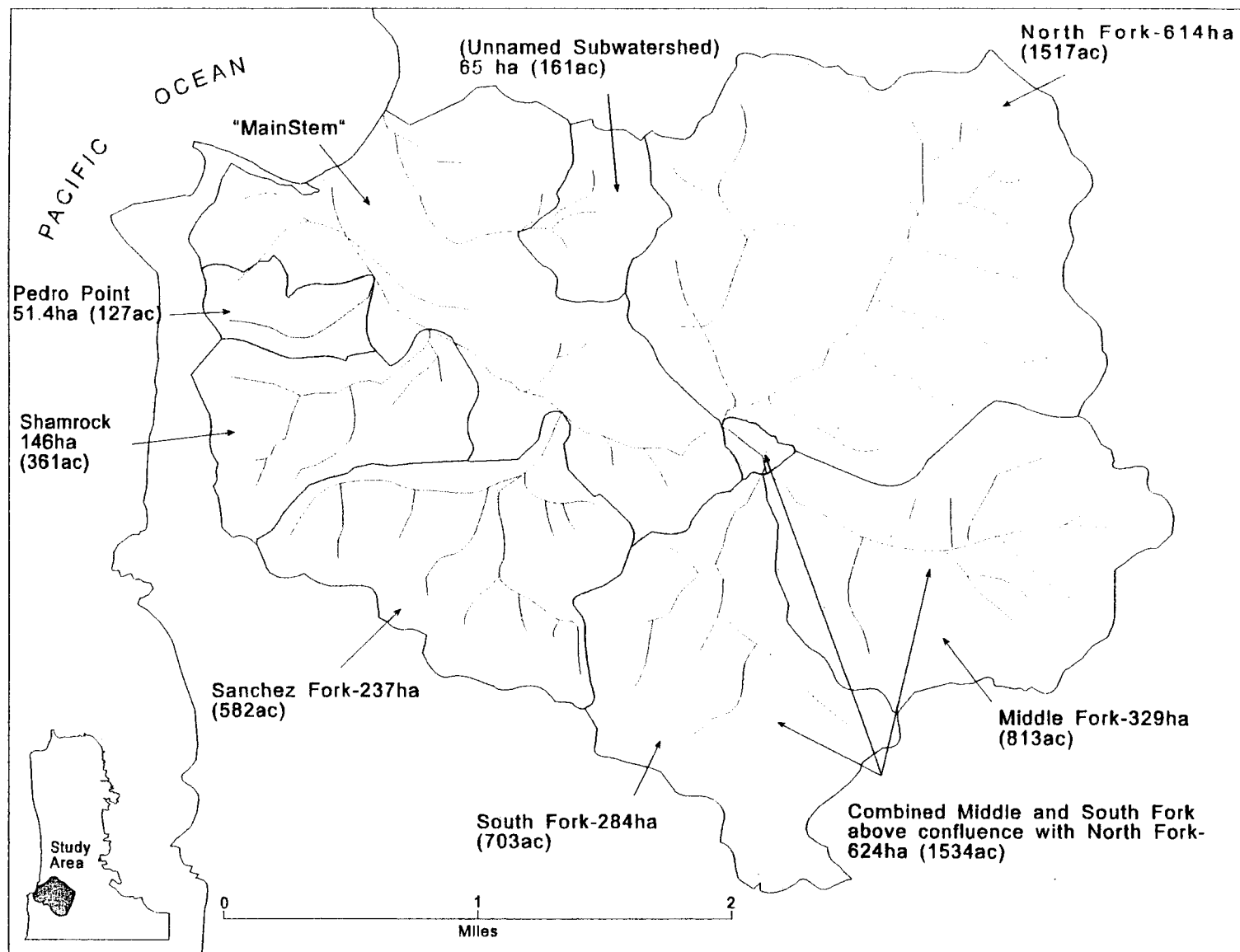


Figure 2. San Pedro Creek Watershed and Subwatershed (San Pedro Creek Watershed Coalition 1999)

The Middle Fork (329 ha) is entirely within public lands, with the exception of a small inclusion of private land that cannot be developed, and thus responds to rainfall events more gradually than the North Fork. It drains sandstone bedrock with minor inclusions of limestone (San Pedro Creek Watershed Coalition 1999), and the riparian canopy is relatively intact for most of the creek's length, although has suffered from incision and unstable banks. The Middle Fork's mean slope is 24.1 percent (USGS Montara Mountain Elevation Model 1999).

The South Fork (284 ha) is entirely within public lands, including San Pedro Valley County Park and North Coast County Water District watershed lands. Much of the drainage is from granitic rocks of Montara Mountain, and this sub-watershed includes the steepest relief in the area. The mean slope of this fork is 26.0 percent (USGS Montara Mountain Digital Elevation Model 1999). While there are few impervious surfaces, the steep slopes and thin soils of the Montara Mountain granites produce relatively rapid runoff, although there is significant infiltration to groundwater, since even smaller tributaries, such as Brooks Creek (in the western section of this sub-watershed) is perennial (San Pedro Creek Watershed Coalition 1999). The Middle & South Forks (624 ha) provide a contrast, in terms of land use and water quality, with the North Fork.

The Sanchez Fork (237 ha) is an important sub-watershed which could provide significant steelhead habitat but unfortunately has a barrier to fish

migration near its confluence with the main stem. The average slope of this fork is 24.4 percent (USGS Montara Mountain Digital Elevation Model 1999). Upland drainage flows from Montara Mountain and San Pedro Mountain. Residential Development is low in density, but new houses are being built far too close to perennial streams and riparian corridors are being destroyed (San Pedro Creek Watershed Coalition 1999).

The Shamrock tributary (146 ha) is not mapped by the USGS (United States Geological Survey), but is perennial. Much of the area is in the Shamrock Ranch, but also includes significant upland drainage from San Pedro Mountain (San Pedro Creek Watershed Coalition 1999). The Shamrock subwatershed mean slope is 18.7 percent (USGS Montara Mountain Elevation Model 1999).

The Pedro Point Fork (51.4 ha) is two separate small watersheds that drain the major portion of the Pedro Point headlands. Not included are small culverted intermittent drainages within the residential areas, though these also feed to the San Pedro Creek outflow at Pacifica State Beach. The two watersheds are areas of steep terrain significantly impacted by off-road motorcycles, and are being managed and restored by the Pacifica Land Trust (San Pedro Creek Watershed Coalition 1999). The mean slope of Pedro Point is 22.0 percent (USGS Montara Mountain Digital Elevation Model 1999).

The Hinton sub-watershed (65 ha) is a small area that has one fairly large landholding, the Hinton Ranch, but is primarily residential except for the steeper

slopes. Its drainage feeds into a ditch that extends to the main stem just below the Adobe bridge. The mean slope of the Hinton subwatershed is 15.1 percent (USGS Montara Mountain Digital Elevation Model 1999). Finally, smaller subwatersheds (106 ha) drain minor upland areas and areas immediately adjacent to the main stem. Much of this area is built over (San Pedro Creek Watershed Coalition 1999).

Climate

The climate in San Pedro Creek watershed is best described as a marine climate with cool, moist winters and mild, foggy summers. Summer temperatures are influenced by low fog in the mornings and a steady flow of marine air from the Pacific Ocean in the afternoons. Because of the marine air flow, extreme temperatures, either hot or cold, are rare. Most of the annual precipitation falls during November through April. The average annual precipitation is about 25 to 30 inches (625 - 750 mm), and the average annual air temperature is about 54 to 58 °F (12 to 14 °C) (USDA 1991). The growing season, the period between the last freezing temperature in spring and the first in fall, ranges from 275 to 350 days. The average surface temperature of the sea water ranges from 51 °F (10 °C) in January to 60 °F (15° C) in August and September. Prevailing winds are onshore from the west while the dominant storm winds are onshore from the southwest (USDA 1991).

Climate plays an important role on the dynamics of the watershed. Fisher and Grimm (1996) mention that temperature and seasonal regimes of precipitation are important drivers of hydrologic and biologic responses of streams due to the interaction of their physical, chemical, and biological components. The effect of climate on stream water quality is discussed in Chapter III.

Geology

The geologic features of San Pedro Creek Watershed are dominated by the Franciscan Complex. This geologic assemblage ranges from 65 to 100 million years old and is the most common found in the Bay Area (Schaal 1975). Five major materials dominate the surficial geology of the watershed (Figure 3): sandstone and sandstone-dominated melange, Montara Mountain granitics, greenstone, alluvium, and conglomerate. In addition, there are scattered outcroppings of serpentinite and limestone. Lower parts of San Pedro Valley are mapped as fill (San Pedro Creek Watershed Coalition 1999).

The sandstone and sandstone-dominated melange is the most common upland rock type. Slopes are typically steep, and soils are well drained (San Pedro Creek Watershed Coalition 1999). On the Montara Mountain granitics,

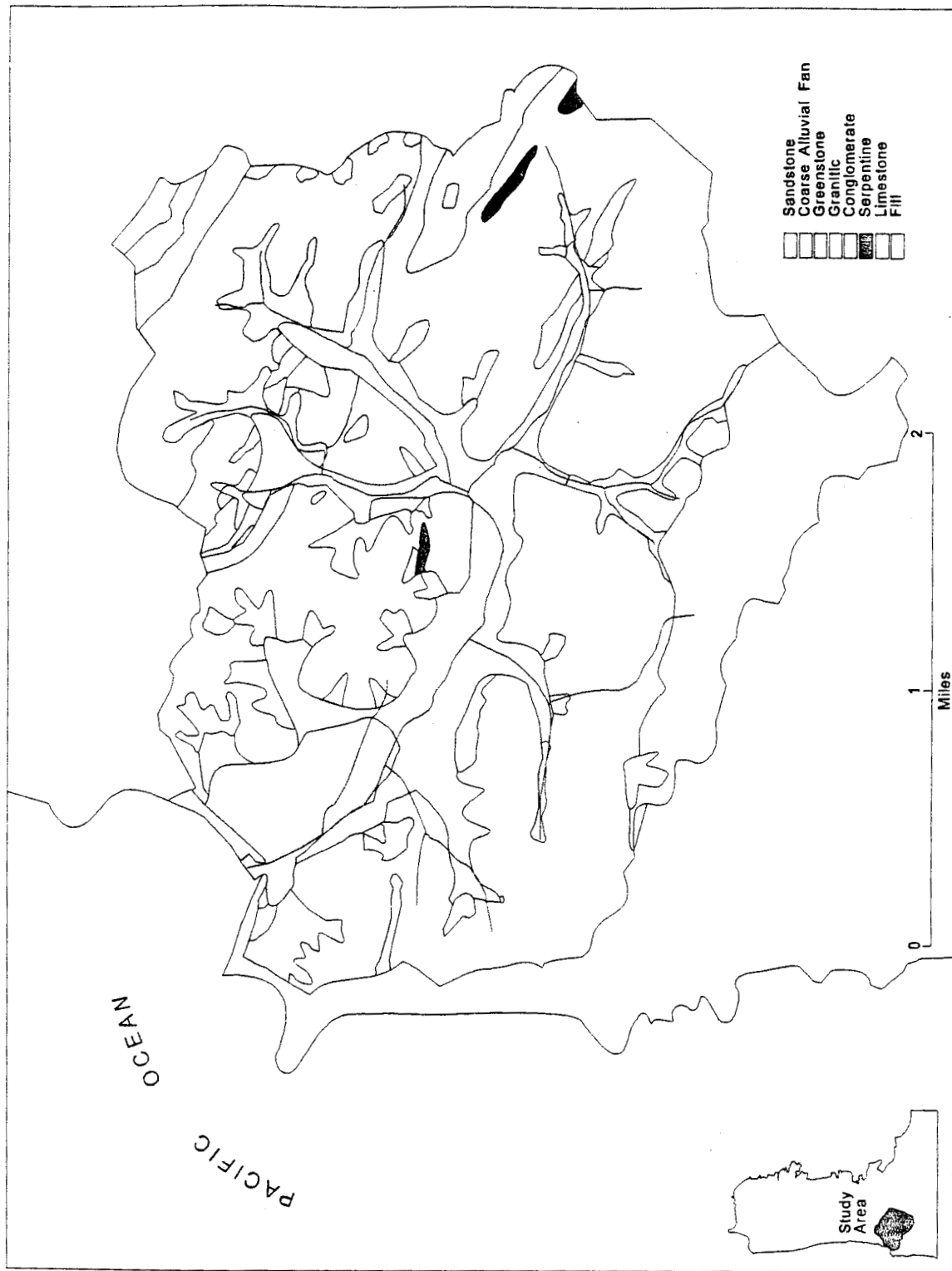


Figure 3. Geology of San Pedro Creek Watershed (San Pedro Creek Watershed Coalition 1999)

which have been classified as tonalite², soils are thin and well drained, with outcrops on slope convexities. Slopes are typically quite steep, since this is all on Montara Mountain, extending to the west to San Pedro Mountain (San Pedro Creek Watershed Coalition 1999). In contrast, greenstone does not tend to produce significant outcrops. This rock is common in the northeast part of the watershed, and is drained by the North Fork (San Pedro Creek Watershed Coalition 1999). Flat valley bottoms are predominantly underlain by gravelly alluvial deposits. Most of these areas are covered by residential development (San Pedro Creek Watershed Coalition 1999). Finally, most of the areas mapped as conglomerate by the USGS appear to be unconsolidated colluvial deposits from debris flows and other slope movements (San Pedro Creek Watershed Coalition 1999). In addition, there are scattered outcrops of serpentinite and limestone. Impressive relief and a pronounced alluvial valley dominate the geomorphology of the 8.2 square mile (approx. 12.8 square kilometer) watershed.

² Batholithic complex. Plutonic rock that contains hornblende, plagioclase, clinopyroxene, biotite and quartz (Faure 1998).

Geomorphology

The bedrock is heavily weathered and fractured from the tectonic and seismic activity typical of the region. The San Andreas Fault, approximately one thousand mile long, runs northwest to southeast two and a half miles east of the watershed and forms the San Andreas Rift Zone. San Pedro Valley is strongly influenced by the geology and the tectonic uplift of Montara Mountain. San Pedro Valley follows the trace of Pilarcitos fault, now thought to be inactive. A lowering of sea level and the gradual deposition of eroded materials from the hillsides formed the valley flats. Landslide activity is also an important contributor to the development of the topography in the watershed. In 1982, as much as eight inches of rain fell over Pacifica in less than 30 hours causing 475 detectable landslides (Howard 1982). This event was considered unusual but indicates the area's potential for episodic earth movement.

Vegetation

The indigenous vegetation of the San Pedro Creek watershed is dominated by different scrub series. Coyote brush scrub is the most common and it clothes the upper south-facing slopes of the northern and eastern parts of the watershed. On shallow ridge soils in this area there is also a wild lilac scrub series. The southern slopes of the watershed present different scrub series where the ridges predominantly face north and there is greater moisture

retention. Here, the upper granitic slopes and lower sandstone layers support chaparral scrub series dominated by manzanita and chinquapin. The lower slopes are dominated by a deciduous hazelnut-cream bush scrub series along the southern watershed slopes from the Middle Fork to the north facing slopes of San Pedro Mountain. These various scrub series cover approximately 80% of the watershed, a second important indigenous vegetation involves a grassland series (Vasey per. comm. 1999).

Other vital indigenous vegetation is the riparian forest series prominent along the Middle Fork and the East Sanchez Fork. Some of the headwaters of San Pedro Creek still maintain a healthy riparian corridor. The health and diversity of the riparian species deteriorates further downstream due to the introduction of invasive ornamentals and the instability of the stream banks. Finally, in different areas, there are non-indigenous forest series consisting of eucalyptus, Monterey pine, and Monterey cypress. These exotic forests probably constitute the second next most- common vegetation type after the different scrub series. Native upland forest, namely the coast live oak forest series, is very rare. Except for the valley and the northern watershed basins, much of the watershed is densely vegetated. The southern watershed (the northern slopes of Montara Mountain) clearly absorbs rain and fog drip which provides water to support perennial springs and creeks except under severe drought conditions (Vasey per. comm. 1999).

Land Use History

The first inhabitants of the San Pedro Valley were the nomadic indigenous people (Ohlone) who lived in small tribes and moved according to seasonal changes in food availability, hence they did not construct permanent settlements. Frequent travels over the same footpaths led to incision of some paths to over a foot in depth. The Ohlone relied on grass seeds as a part of their diet and in order to maintain the grasslands (consisting of wild ryes, junegrass, pine bluegrass, and deergrass) they set fire to the meadows to prevent the growth of coastal scrub and trees. Willow and alder trees, part of the riparian vegetation, were the only trees to be found in the valley. The valley bottomland at the time of Spanish discovery has been described as lush with creeks and vegetation. Although the creeks remain today, they have been highly altered by human settlement (Margolin 1978 and Culp 1999).

In the late 1700's the Spanish built an *asistencia* on San Pedro Creek and began farming approximately 90 acres of fields in the valley. Cattle were introduced into the area and would graze the hillsides above the valley. After 1794, the *asistencia* was officially abandoned although a few Ohlone and/or Spanish settlers remained to farm and graze their cattle. A letter from 1800 mentions that there were 6,000 head of cattle in the valley and an 1835 inventory of mission properties listed about 4,000 head of cattle (La Peninsula 1961, Savage 1983).

After the independence of Mexico the *asistencia* was converted into the Rancho San Pedro (Figure 4), under the control of Francisco Sanchez. The major products of the Rancho were cowhides, tallow, and wool. During this period the San Pedro Valley, like much of the rest of the coast between Monterey and San Francisco, was used as pasture for huge herds of cattle. Several decades of over-grazing of the hillsides introduced non-native plant species and altered the grassland landscape created by the Ohlone. It is probable that the cattle damaged the stream banks and the riparian vegetation along the coastal creeks as well. Both the siltation of streambed gravels from bank deterioration and the loss of shade from damaged riparian vegetation would have had a negative impact on the steelhead trout that used San Pedro Creek and its tributaries to spawn. Sanchez also introduced irrigation of the valley bottom. Ditches dug from the creek irrigated the fields in the valley and a small check dam was built upstream from the fields. When the Rancho was founded the creek ran only a few feet below ground level, but since then the creek has incised a deep V-shaped channel that runs up to 15 feet (4.6 meters) below the valley floor (Culp 1999).

Land became a prime commodity in California during the Gold Rush of 1849 as Americans moved into the area. The San Pedro Valley was divided into smaller plots for dairy ranches and farming. Farming of various crops was the

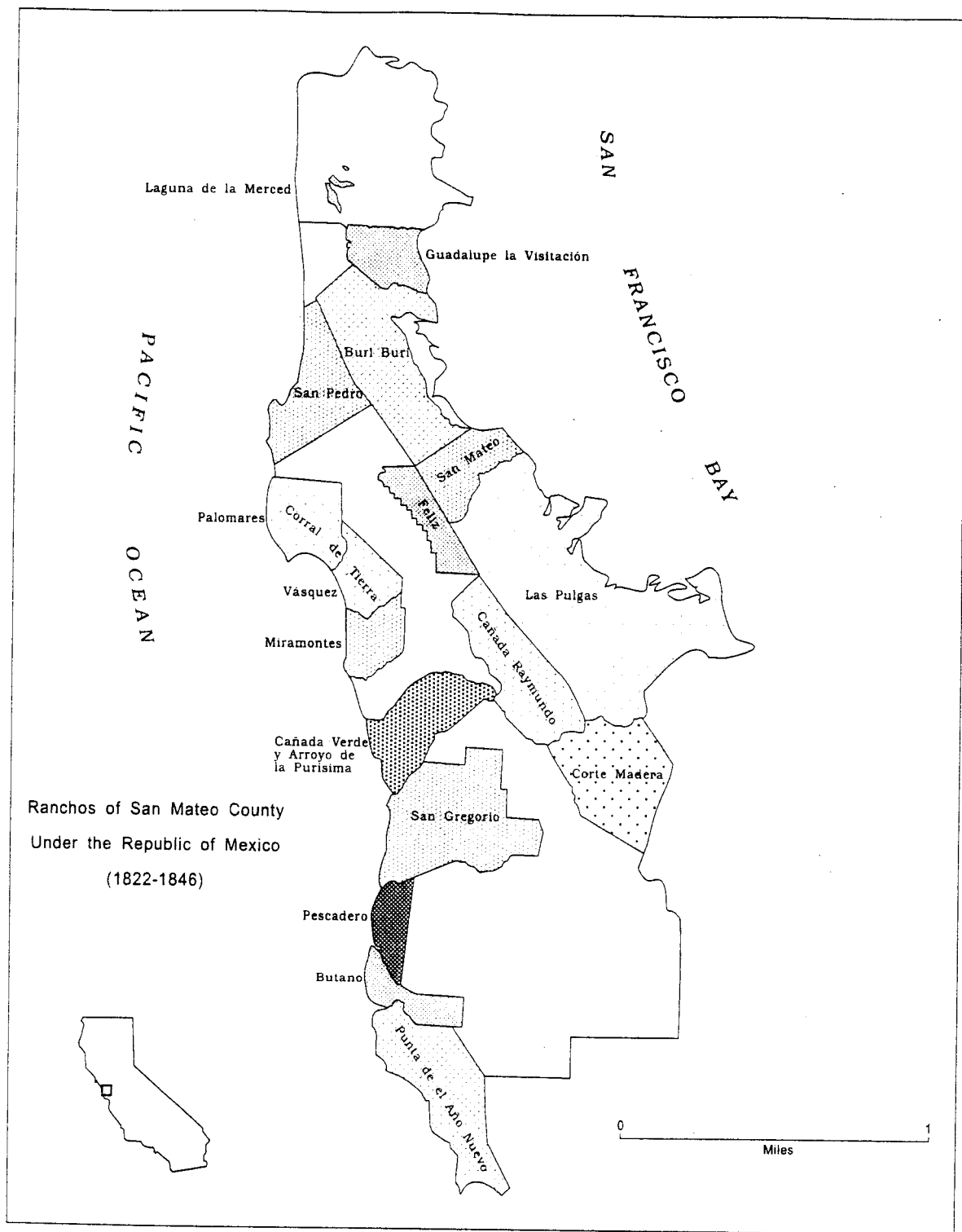


Figure 4. Ranchos of San Mateo County (1822-1846) (Stanger 1963)

main activity in the San Pedro Valley until the end of WWII. During this time, small farmhouses and fields dominated the landscape, and inhabitants planted trees (blue-gum eucalyptus, Monterey cypress, and Monterey pine) which changed the grassland landscape even further.

In the 1950's a man named Andy Oddstad bought up much of the property in the San Pedro Valley with plans to develop the area into a recreational, residential, and commercial area. By 1953, the first non-farming residents moved into the valley and in 1955 the Linda Mar shopping center was built. The housing developments in the San Pedro Valley occurred on a parcel-by-parcel basis and at times tract housing was built adjacent to artichoke farms (Culp 1999).

A suburban landscape dominates the valley today, although a few ranches remain. The creek, although culverted and buried in places, still flows and attempts are currently being made to more fully integrate the creek into suburban landscape (Culp 1999).

Land use

Land use is a major factor influencing the watershed, and presents the most significant challenges in improving the quality of runoff to the creek (Table 2). The headwaters and most of the south slope are relatively pristine, with "shrub and brush rangeland" the most extensive land cover, but the remainder of the watershed is fairly urbanized. The interior slopes and valley floor are

developed with housing, schools, roads, and shopping centers; residential land uses is the second most common category. "Evergreen forest" appears as a significant category, reflecting the extent of primarily Eucalyptus forest with minor areas of pines and cypress on Pedro Point (Figure 5).

Land use impacts are especially significant in specific areas. Significant physical impacts to the stream include past channelization of the lower reach for agriculture and the extension of impervious surfaces, for example urban encroachment and the complete culverting of the North Fork in the 1970's. Water quality problems appear to relate most significantly to storm drain inputs, especially along the culverted North Fork. Moreover, serious consideration is given to a grazing history that exceeds 300 years, the installation of at least four flash-board dams for agricultural water supply, undersized box culverts that have constricted flows for nearly 50 years and changes in vegetation as European settlers displaced Native Americans (Ohlone) (San Pedro Creek Watershed Coalition 1999).

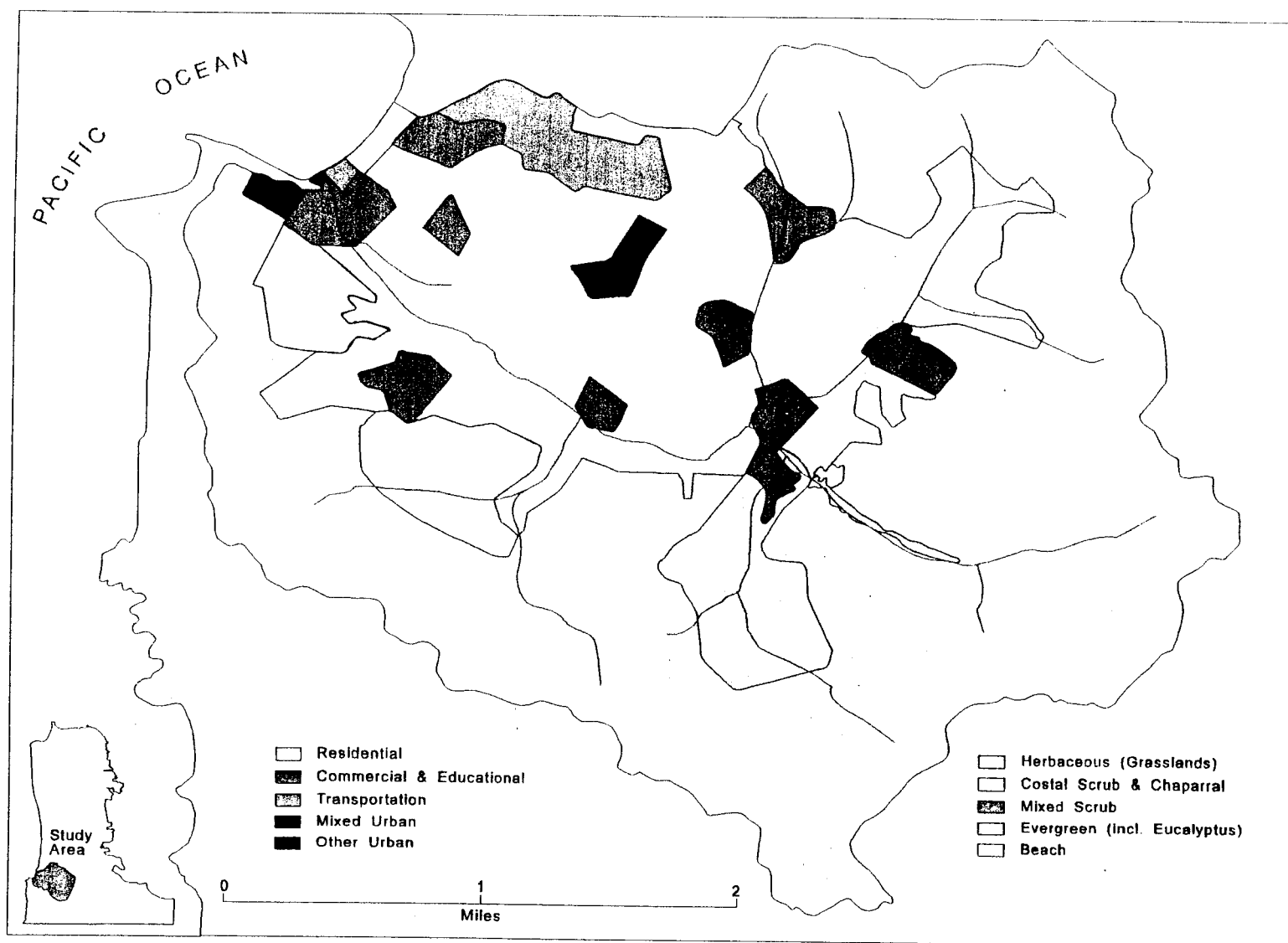


Figure 5. Land Use Categories in San Pedro Creek Watershed (San Pedro Creek Watershed Coalition 1999)

Table 2. Major land-use/land-cover categories in San Pedro Creek Watershed

Land use/Land-use cover categories	Hectares (Ha)	Acres	Mi ²
Shrub and brush rangeland (coastal scrub and chaparral)	1206.85	2982.19	4.6596
Residential	560.36	1384.69	2.1636
Evergreen Forest	170.15	420.45	0.6570
Commercial	114.08	281.90	0.4450
Mixed rangeland	44.40	109.70	0.1714
Other urban or built-up	12.41	30.68	0.0479
Mixed urban or built up	6.84	16.90	0.0264
Beach	5.28	13.06	0.0204
Herbaceous rangeland	4.45	10.99	0.0172
Transport, communication and utilities	2.26	5.59	0.0087
TOTAL			8.2172

Source: San Pedro Creek Watershed Coalition 1999.

The material reviewed in this chapter provides critical physical, cultural and ecological background information required to understand the characteristics and dynamics of the area of study. The next chapter reviews literature about water quality, including field studies using water quality analyses.

CHAPTER III

LITERATURE REVIEW

This chapter will provide an overview of some critical physical, chemical and biological parameters for stream water quality assessments, major water quality issues, and previous and concurrent water quality studies in these aquatic systems. The review of this literature and past research in stream water quality studies provide important information to ensure proper research design and to support conclusions reached by this study.

SECTION I. STREAMS WATER QUALITY

Different activities such as return flows from agricultural land (runoff), power plants (cooling water), industrial facilities (discharge of treated process effluents, cooling waters, and storm water runoff), and urban areas (treated municipal wastewater and storm water runoff) affect the quality of water in receiving streams, and may indirectly affect groundwater quality. Thus, at a given river station, water quality depends on many factors, including i) the proportion of surface run-off and groundwater, ii) reactions within the river system governed by internal processes, iii) the mixing of water from tributaries of different quality, and iv) inputs of pollutants (Chapman 1997). Therefore, water quality in surface and ground waters throughout the world varies considerably

(Malina 1996). Physical, chemical, and biological characteristics of different sources of water are summarized in Table 3.

Some critical physical, chemical and biological parameters for aquatic ecosystems are: pH, temperature, conductivity, hardness, alkalinity, turbidity, metals, volatile organic compounds, dissolved oxygen, total suspended particles, total and fecal coliforms, enterococcus and nutrients such as nitrate, nitrites, nitrogen ammonia, and phosphorus (Goldman and Horne 1983, Tchobanoglous and Schroeder 1985, Clesceri *et al.* 1989, Bartram and Helmer 1996, Malina 1996, Margaleff 1996, Chapman 1997, Eyre and Pepperell 1999). Consequently, these parameters are considered and analyzed in this chapter.

Table 3. Physical, chemical and biological characteristics of various water sources

Characteristics	Typical surface Water	Typical Groundwater	Domestic wastewater (U.S.)
Physical			
Turbidity (NTU)	--	--	--
Solids, total (mg/L)	--	--	700
Suspended (mg/L)	> 50	--	200
Settleable (mg/L)	--	--	10
Volatile (mg/L)	--	--	300
Filterable dissolved (mg/L)	< 100	> 100	500
Color (Color units)	--	--	--
Odor, number	--	--	--
Temperature (°C)	0.5-30	2.7-25	10-25
Temperature (°F)	33-86	37-77	50-77
Chemical Inorganic matter			
Alkalinity (mg/L as CaCO ₃)	< 100	> 100	> 100
Hardness (mg/L as CaCO ₃)	< 100	> 100	--
Chlorides (mg/L)	50	200	< 100
Calcium (mg/L)	20	150	--
Heavy metals (mg/L)	--	0.5	--
Nitrogen (mg/L)	< 10	< 10	40
Organic (mg/L)	5	--	15
Ammonia (mg/L)	--	--	25
Nitrate (mg/L)	< 5	5	0
Total Phosphorus (mg/L)	--	--	12
Sulfate (mg/L)	--	--	--
PH (pH units)	--	6.5-8	6.5-8.5
Chemical Organic matter			
Total organic Carbon (mg/L)	< 5	--	150
Fats, oils and greases (mg/L)	--	--	100
Pesticides (mg/L)	< 0.1	--	--
Phenols (mg/L)	< 0.001	--	--
Surfactants (mg/L)	< 0.5	< 0.5	--
Chemical Gases			
Oxygen (mg/L)	7.5	7.5	< 1.0
Biological			
Bacteria MPN/100mL	< 2000	< 100	10 ⁸ -10 ⁹
Viruses, plaque forming units (pfu)	< 10	< 1	10 ² -10 ⁴

Source: National Interim Primary Drinking Water Regulations 1975.

PHYSICAL WATER QUALITY VARIABLES OF STREAMS

Temperature, suspended solids, turbidity, conductivity and stream flow play an important role in the ecology of aquatic systems. Quantitative measurements of these parameters are necessary for the determination of water quality, trends and dynamics of fresh water systems.

Temperature

The temperature of fresh water normally varies from 0-35 °C (32 to 95 °F) depending on the source, depth and season. Over much of the United States, river waters will vary from 0.5 to 3.0 °C (32.9 to 37.4 °F) (Tchobanoglous and Schroeder 1985, Chapman 1997). The temperature of water affects some of the important physical properties and characteristics of water, such as density, specific weight, viscosity, surface tension, thermal capacity, vapor pressure, specific conductivity and conductance, salinity, and solubility of dissolved gases (Tchobanoglous and Schroeder 1985, Chapman 1997). Temperature is a very important physical parameter for aquatic life. Aquatic organisms from microbes to fish are dependent on certain temperature ranges for optimal health (Clesceri *et al.* 1989). Optimal temperatures for fish depend on the species: some survive best in colder water, whereas other prefer warmer water. Benthic macroinvertebrates are also sensitive to temperature and will move in the aquatic system to find their optimal temperature. If temperatures are outside their

Table 2. Major land-use/land-cover categories in San Pedro Creek Watershed

Land use/Land-use cover categories	Hectares (Ha)	Acres	Mi ²
Shrub and brush rangeland (coastal scrub and chaparral)	1206.85	2982.19	4.6596
Residential	560.36	1384.69	2.1636
Evergreen Forest	170.15	420.45	0.6570
Commercial	114.08	281.90	0.4450
Mixed rangeland	44.40	109.70	0.1714
Other urban or built-up	12.41	30.68	0.0479
Mixed urban or built up	6.84	16.90	0.0264
Beach	5.28	13.06	0.0204
Herbaceous rangeland	4.45	10.99	0.0172
Transport, communication and utilities	2.26	5.59	0.0087
TOTAL			8.2172

Source: San Pedro Creek Watershed Coalition 1999.

The material reviewed in this chapter provides critical physical, cultural and ecological background information required to understand the characteristics and dynamics of the area of study. The next chapter reviews literature about water quality, including field studies using water quality analyses.

CHAPTER III

LITERATURE REVIEW

This chapter will provide an overview of some critical physical, chemical and biological parameters for stream water quality assessments, major water quality issues, and previous and concurrent water quality studies in these aquatic systems. The review of this literature and past research in stream water quality studies provide important information to ensure proper research design and to support conclusions reached by this study.

SECTION I. STREAMS WATER QUALITY

Different activities such as return flows from agricultural land (runoff), power plants (cooling water), industrial facilities (discharge of treated process effluents, cooling waters, and storm water runoff), and urban areas (treated municipal wastewater and storm water runoff) affect the quality of water in receiving streams, and may indirectly affect groundwater quality. Thus, at a given river station, water quality depends on many factors, including i) the proportion of surface run-off and groundwater, ii) reactions within the river system governed by internal processes, iii) the mixing of water from tributaries of different quality, and iv) inputs of pollutants (Chapman 1997). Therefore, water quality in surface and ground waters throughout the world varies considerably

(Malina 1996). Physical, chemical, and biological characteristics of different sources of water are summarized in Table 3.

Some critical physical, chemical and biological parameters for aquatic ecosystems are: pH, temperature, conductivity, hardness, alkalinity, turbidity, metals, volatile organic compounds, dissolved oxygen, total suspended particles, total and fecal coliforms, enterococcus and nutrients such as nitrate, nitrites, nitrogen ammonia, and phosphorus (Goldman and Horne 1983, Tchobanoglous and Schroeder 1985, Clesceri *et al.* 1989, Bartram and Helmer 1996, Malina 1996, Margaleff 1996, Chapman 1997, Eyre and Pepperell 1999). Consequently, these parameters are considered and analyzed in this chapter.

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Heavy metals (mg/L)	--	0.5	--
Nitrogen (mg/L)	< 10	< 10	40
Organic (mg/L)	5	--	15
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optimal ranges for a prolonged period of time, organisms are stressed and can die (Goldman and Horne 1983, USEPA 1991, Chapman 1997). For example, the steelhead trout cannot tolerate water temperatures above 27 °C (80 °F), and its range for optimum growth lies between 14 and 16 °C (57.8 and 60.8°F) (Magaud *et al.* 1997, Rowland 1998).

The San Francisco Bay Regional Water Quality Control Board (1995) reports that the temperature of any cold or warm fresh water habitat shall not be increased by more than 5 °F (2.7 °C) above natural receiving water temperature. Temperature affects the oxygen content of the water (oxygen levels become lower as temperature increases); the rate of photosynthesis by aquatic plants; the metabolic rates of aquatic organisms; and the sensitivity of organisms to toxic wastes, parasites and diseases (USEPA 1991, Margaleff 1996, Chapman 1997).

Solids

Solids refer to matter suspended or dissolved in water. The term “solids” is widely used for the majority of compounds which are present in natural waters and remain in a solid state after evaporation. Solids are expressed as milligrams pro liter of solids (*mg/L*). Suspended solids may be organic or inorganic materials originating from a wide variety of sources, such as decaying vegetation algae, solids discharged by industries and municipalities, urban and agricultural runoff, and physical degradation of geological formations. Total suspended

solids (TSS) and total dissolved solids (TDS) correspond to non-filtrable and filtrable residues, respectively (Mays 1996, USEPA 1997). The San Francisco Regional Water Quality Control Board reports as a standard that suspended solids loads and suspended sediment discharge rate of surface waters shall not be altered in such a manner as to cause nuisance or adversely affect beneficial uses (San Francisco Bay Regional Water Quality Control Board 1995). Aquatic organisms would survive better in environments with less than 80 mg/L of total suspended solids (Rowland 1998). Solids may affect water quality adversely in a number of ways. Solids raise temperature of water, this in turns lowers dissolved oxygen content. Suspended materials can smother fish eggs and bury macroinvertebrates, clog fish gills and reduce disease resistance. Stream productivity could also be affected due to decrease in light penetration (Margaleff 1996, Liddle 1997).

Turbidity

Another important physical characteristic of water is turbidity. This parameter is defined as the measure of light-transmitting properties of water and is comprised of suspended and colloidal material (Clesceri *et al.* 1989). Turbidity is expressed as nephelometric turbidity units (NTU). Normal values range from 1 to 1,000 NTU and levels can be increased by the presence of organic matter pollution, other effluents, or run-off with a high suspended matter content

(Chapman 1997). Turbidity can affect the color of the water. Higher turbidity increases water temperatures because suspended particles absorb more heat. This, in turn, reduces the concentration of dissolved oxygen (DO) because warm water holds less DO than cold. Higher turbidity also reduces the amount of light penetrating the water, which reduces photosynthesis and the production of DO. Suspended materials can clog fish gills, reducing resistance to decrease in fish, lower growth rates, and affecting egg and larva development. As the particles settle, they can blanket the water body bottom, and smother fish eggs and benthic microinvertebrates (USEPA 1991, Clesceri *et al.* 1989). Moreover, turbidity is associated with microorganisms. Viruses and bacteria become attached to particulate material, becoming potential pathogens. The suspended solids causing turbidity are important in that they may alter light penetration; they may also serve as food for various species of invertebrates. Where the current slows, many of the suspended solids may settle on the bottom, affecting the nature of the substrate there (Goldman and Horne 1983). The San Francisco Bay Regional Water Quality Control Board (1995) requires that waters be free of changes in turbidity that cause nuisance or adversely affect beneficial uses. Moreover, Rowland (1998) reports that for steelhead trout, the desirable turbidity value should be below 80 NTU.

Table 4. Water quality of streams and rivers physical characteristics

Water Quality Parameter	Typical value	Observed Ranges
Temperature (°C)	Variable	0-30
Turbidity (NTU)	----	0-3
Total Suspended Solids (mg/L)	10-110	0.3-50.000

Source: McCutcheon 1993.

Stream Flow

Stream flow, or discharge, is the volume of water that moves past a designated point over a fixed period of time. It is often expressed as cubic feet per second (ft³/sec) and cubic meters per second (m³/sec). The flow of a stream is directly related to the amount of water moving off the watershed into the stream channel. It is affected by weather, increasing during rainstorms and decreasing during dry periods. It also changes during different seasons of the year, decreasing during the summer months when evaporation rates are high and riparian vegetation is actively growing and removing water from the ground. August and September are usually the months of lowest flow of most streams and rivers in most of the United States (USEPA 1997).

Flow is a function of water volume and velocity. It is important because of its impact on water quality and on the living organisms and habitats in the stream. Large, swiftly flowing rivers can receive pollution discharges and be little

affected, whereas small streams have less capacity to dilute and degrade wastes (USEPA 1997).

Stream velocity, which increases as the volume of the water in the stream increases, determines the kinds of organisms that can live in the stream; some need fast-flowing areas; other need quiet pools. It also affects the amount of silt and sediment carried by the stream. Sediment introduced to quiet, slow-flowing streams will settle quickly to the bottom. Fast moving streams will keep sediments suspended longer in the water column. Lastly, fast-moving streams generally have higher levels of dissolved oxygen than slow streams because they are better aerated (USEPA 1997).

Physical water quality variables cannot be divorced from the water chemical composition. The next section discusses the most significant chemical variables in water quality analysis.

CHEMICAL WATER QUALITY VARIABLES OF STREAMS

Changes in the chemical composition of the water are followed by significant changes in the structure of the biota. Some critical chemical parameters for aquatic ecosystems are pH, alkalinity, hardness, conductivity, dissolved oxygen, nitrite, nitrate, nitrogen ammonia, phosphorus, heavy metals, and volatile organics (Goldman and Horne 1996, Margaleff 1996, Tate *et al.* 1999).

pH

pH (potential hydrogen) is an important variable in water quality assessments influencing many biological and chemical processes within a water body and all processes associated with water supply. The pH indicates the alkalinity or acidity of a substance as ranked on a scale from 1.0 to 14.0 (from very acid to very alkaline, with pH 7 representing a neutral condition). The pH is controlled by the dissolved chemical compounds and biochemical processes in aquatic systems (Faus and Aly 1981, Clesceri *et al.* 1989). The largest variety of aquatic animals, like the steelhead trout, prefer a range of 6.5-8.5 and this is the range required by The San Francisco Bay Regional Water Quality Control Board (1995). pH outside this range reduces the biodiversity in fresh water ecosystems because it stresses the physical systems of most organisms and can reduce reproduction. Low pH can also allow toxic elements and compounds to become mobile and “available” for uptake by aquatic plants and animals. This can produce conditions that are toxic to aquatic life, particularly to sensitive species (USEP 1991). Therefore, each species has a pH tolerance level. Table 4 shows some examples of organisms at different levels in the food chain and their pH tolerance ranges. Under or above these values, changes in primary productivity (measurement of photosynthesis), oxygen production, and even mortality could occur at a different levels in the food chain (Tchobanoglous and Schroeder 1985, Clesceri *et al.* 1989, Matuk *et al.* 1997).

Table 5. pH tolerance ranges in some organisms at different levels in the aquatic food chain.

Organism	pH tolerance ranges
<i>Chlorella vulgaris</i> (algae)	8.5
<i>Daphnia pulex</i> (microcrustacean)	6.5-8.5
<i>Oncorhynchus mykiss</i> (fish)	7.5-8.5
<i>Lebistes reticulatus</i> (fish)	7.5-8.5

Source: Tchobanoglous and Schroeder 1985, Clesceri *et al.* 1989, Matuk *et al.* 1997

Alkalinity

Another important chemical parameter in stream water quality studies related to pH is alkalinity, a measure of the capacity of water to neutralize acids. Alkaline compounds in the water such as bicarbonates, carbonates, and hydroxides remove H⁺ ions and lower the acidity of water. Without this acid-neutralizing capacity, any acid added to an aquatic ecosystem would cause an immediate change in the pH. Measuring alkalinity is important in determining a water body's ability to neutralize acid pollution from rainfall or wastewater.

Alkalinity is influenced by rocks and soils, salts, certain plant activities, and certain industrial wastewater discharges (USEPA 1991). Alkalinity is usually measured as either mg/L (milligrams per liter) or m-eq/L (mili-equivalents) CaCO₃ (Calcium Carbonate) (1 m-eq = 50 mg/L CaCO₃). A typical fresh water alkalinity value is 150 mg/L, and observed ranges are between 5-250 mg/L (Mays 1996).

Aquatic organisms tolerate alkalinity values between 10-400 mg/L CaCO₃.

Waters of low alkalinity (<20 mg/L) are poorly buffered, and the removal of CO₂

during photosynthesis results in rapidly rising pH. Waters with alkalinities less than 20 mg/L or more than 250 mg/L CaCO_3 usually are unproductive because they contain too little carbon dioxide for primary production (Rowland 1998).

Hardness

Hardness is the total concentration of metal ions (primarily calcium (Ca^{+2}) and magnesium (Mg^{+2})) in water expressed in mg/L of equivalent calcium carbonate (CaCO_3). Fresh waters containing low concentrations (<10 mg/L) of calcium carbonate are termed “soft”, and those with high concentrations (>200 mg/L) are “hard”. Hardness (expresses as mg/L CaCO_3) observed for streams and rivers throughout the world ranges between 1 to 1,000 mg/L CaCO_3 . Typical concentrations are 47 to 74 mg/L CaCO_3 . Hardness criteria for coldwater fish is between 10-400 mg/L CaCO_3 (Mays 1996, Rowland 1998).

Fresh water aquatic life criteria for certain metals are expressed as a function of hardness because hardness and/or water quality characteristics that are usually correlated with hardness can reduce or increase the toxicity of some metals. Hardness is used as a surrogate for a number of water quality characteristics which affect the toxicity of metals in a variety of ways. Increasing hardness has the effect of decreasing the toxicity of metals. Water quality criteria to protect aquatic life may be calculated at different concentrations of hardnesses

measured in milligrams per liter (mg/L) as calcium carbonate (CaCO_3) (USEPA 2000).

Electrical Conductivity

Yet another critical chemical parameter for aquatic life is electrical conductivity (EC). EC is a measure of the ability of water to pass an electrical current, and is measured in micromhos per centimeter ($\mu\text{mhos/cm}$) or microsiemens per centimeter ($\mu\text{S/cm}$) (USEPA 1991). EC in water is affected by the presence of inorganic dissolved solids such as chloride, nitrate, sulfate, and phosphate anions (ions that carry a negative charge) or sodium, magnesium, calcium, iron, and aluminum cations. EC is also affected by temperature (the warmer the water, the higher the conductivity) and by the geology of the area. Moreover, discharges can change the water body conductivity due to the presence of chloride, phosphate and nitrates (USEPA 1991). Fresh water has an EC range from 10 to 1,000 $\mu\text{S/cm}$ but may exceed 1,000 $\mu\text{S/cm}$, especially in polluted waters, or those receiving large quantities of land run-off (Chapman 1997).

Alkalinity, hardness and conductivity are closely related since these parameters measure the number of some anions and cations in the water, as it was mentioned before. Alkalinity and conductivity can sometimes be indicators

of human activities in surface waters (Hirose and Kuramoto 1981, Vaisanen *et al.* 1997).

A summary of the typical values and observed ranges of the physical parameters previously analyzed in streams and rivers throughout the world is presented in Table 4. These data provide an insight into the wide variability of natural water quality. The quality of natural water sources used for recreational purposes, agricultural irrigation, and municipal and industrial supplies should be established in terms of the specific water-quality parameters which most affect the possible use of the water (Mays 1996).

Dissolved Oxygen

Of the dissolved gases present in running water, oxygen is the most abundant and important. Oxygen in aquatic systems is measured in its dissolved form as dissolved oxygen (DO, units: mg/L). DO is important in natural water because oxygen is required by many microorganisms and fish. Although oxygen is a major component of air (21%) it is only slightly soluble in water. The solubility of oxygen in water decreases with increasing temperature, as well as with increasing salinity and air pressure or altitude. Consequently, fresh water can hold more oxygen in winter than in summer (Rowland 1992, Wetzel and Likens 2000). Typical dissolved oxygen concentrations reported for natural waters throughout the world are 3 to 9 mg/L, which is the concentration of

dissolved oxygen in fresh water at saturation at 20 °C (68 °F). The observed range of dissolved oxygen concentrations reported worldwide is 0 mg/L (anoxic conditions) to 19 mg/L (supersaturated conditions) (Waite 1984). Supersaturated conditions are caused by algal bloom. Under anoxic conditions, or periods of zero dissolved oxygen in the water, reduced forms of chemical species are formed and frequently lead to the release of undesirable odors (Waite 1984, Margaleff 1996). The San Francisco Bay Regional Water Quality Control Board (1995) reports that dissolved oxygen minimum values should be in a range of 5 to 7 mg/L. The steelhead trout (*Oncorhynchus mykiss*) will not survive prolonged exposure to concentrations below 5 mg/L. Based on toxicity tests, concentrations under 1.75 mg/L after 96 hours are considered lethal for the trout (Magaud *et al.* 1997). Fish need a higher oxygen requirements compared to other aquatic organisms such as micro-crustaceans and algae because of their size (Rowland 1998). In general, the actual amount of oxygen present in the water is related to the character of the current, the water temperature, and the presence of respiring plants and animals (Chapman 1997).

Nitrates, Nitrites and Nitrogen Ammonia

Nitrogen is essential for living organisms as an important constituent of proteins, including genetic material. Nitrogen is a complex element that can exist in seven states of oxidation. From a water quality standpoint, the nitrogen

containing compounds that are of most interest are organic nitrogen, ammonia (NH_3), nitrite (NO_2^-) and nitrate (NO_3^-). Of these, nitrate is usually the most important form of combined nitrogen found in natural waters because it is an essential nutrient for aquatic plants. It may be biochemically reduced to nitrite by denitrification processes, usually under anaerobic conditions. The nitrite ion is rapidly oxidized to nitrate (Effler *et al.* 1990). Natural sources of nitrate to surface waters include igneous rocks, land drainage and plant and animal debris. Seasonal fluctuations can be caused by plant growth and decay. Natural concentrations, which seldom exceed 1 mg/L NO_3 , may be enhanced by municipal and industrial wastewaters, including leachates from waste disposal sites and sanitary landfills. When influenced by human activities, surface waters can have nitrate concentrations up to 5 mg/L NO_3 . Concentrations in excess of 5 mg/L NO_3 usually indicate pollution by human or animal waste, or fertilizer run-off (Hagebro *et al.* 1983). Aquatic organisms can tolerate nitrate ranges between 0-100 mg /L (USEPA 1986).

Nitrite (NO_2^-) concentrations in fresh waters are usually very low, 0.001 mg/L NO_2 , and rarely higher than 1 mg/L. High nitrite concentrations are generally indicative of industrial effluents and are often associated with unsatisfactory microbiological quality of water. Determination of nitrate plus nitrite in surface waters gives a general indication of the nutrient states and the level of organic pollution. Consequently, these parameters are included in most

basic water quality surveys and multi-purpose or background monitoring programmes (Chapman 1997). Aquatic organisms tolerate nitrite values of 0.1 mg/L (USEPA 1986).

Ammonia (NH_3) occurs naturally in water bodies arising from the breakdown of nitrogenous organic and inorganic matter in soil and water, excretion by biota, reduction of nitrogen gas in water by micro-organisms and from gas exchange with the atmosphere. It is also discharged into water bodies by some industrial processes, and also as a component of municipal or community waste. In water, the total ammonia-nitrogen occurs in two forms, unionized ammonia (NH_3) which is toxic to fish, and the ammonium ion (NH_4^+) which is relatively non-toxic, except at extremely high concentrations. At certain pH levels, high concentrations of ammonia are toxic to aquatic life and, therefore, detrimental to the ecological balance of water bodies. Unpolluted water contains small amounts of ammonia and ammonia compounds, usually less than 0.1 mg/L as nitrogen. The San Francisco Bay Regional Water Quality Control Board (1995) does not require a reporting limit for total ammonia nitrogen. Higher concentrations (> 0.1 mg/L) could be an indication of organic pollution such as from domestic sewage, industrial waste and fertilizer run-off. Ammonia is, therefore, a useful indicator of organic pollution. Natural seasonal fluctuations also occur as a result of the death and decay of aquatic organisms, particularly

phytoplankton and bacteria in nutritionally rich waters (Goldman *et al.* 1983, Hagebro *et al.* 1983, Margaleff 1996, Chapman 1997, Freifelder *et al.* 1998).

Phosphorus

Like nitrogen, phosphorus is an essential nutrient for living organisms and exists in water bodies in both dissolved and particulate forms. It is generally the limiting nutrient for algal growth and, therefore, controls the primary productivity of a water body. Artificial increases in concentrations due to human activities are the principal cause of eutrophication (Clesceri *et al.* 1989)

Natural sources of phosphorus are mainly the weathering of phosphorus-bearing rocks and decomposition of organic matter. Domestic waters (particularly those containing detergents), industrial effluents and fertilizer run-off contribute to elevated levels in surface waters. Phosphorus associated with organic and mineral constituents of sediments in water bodies can also be mobilized by bacteria and released to the water column. Phosphorus is rarely found in high concentrations in fresh water as it is actively taken up by plants. As a result there can be considerable seasonal fluctuation in concentrations in surface waters. In most natural surface waters, phosphorus ranges from 0.01 to 0.03 mg/L $\text{PO}_4\text{-P}$ (USEPA 1986). Concentrations as low as 0.001 mg/L $\text{PO}_4\text{-P}$ may be found in some pristine waters and as high as 200 mg/L $\text{PO}_4\text{-P}$ in some enclosed saline waters (Chapman 1997).

As phosphorus is an essential component of the biological cycle in water bodies, it is often included in basic water quality surveys or background monitoring programmes. Together with nitrogen, phosphorus in excess amounts can accelerate eutrophication, causing dramatic increase in aquatic plant growth and changes in types of plants and animals in the lake. This, in turn, affects dissolved oxygen, temperature, and other indicators (Mays 1996).

Metals

The ability of a water body to support aquatic life, as well as its suitability for other uses, depends on many trace elements. Some metals, such Zinc (Zn) and Copper (Cu), when present in trace concentrations are important for the physiological functions of living tissue and regulate many biochemical processes (Faust and Aly 1981). However, some metals discharged into natural waters as increased concentrations in sewage, industrial effluents or from mining operations can have severe toxicological effects on humans and the aquatic ecosystem. Water pollution by heavy metals as a result of human activities is causing serious ecological problems in many parts of the world. This situation is aggravated by the lack of natural elimination processes for metals. As a result, metals shift from one component within the aquatic environment to another, often with detrimental effects. Where sufficient accumulation of the metals in biota occurs through food chain transfer, there is also an increasing toxicological risk

for humans. As a result of adsorption and accumulation, the concentration of metals in bottom sediments is much higher than in the water above and this sometimes causes secondary pollution problems (Faust and Aly 1981, Waite 1984).

Generally, trace amounts of metals are always present in fresh waters from the weathering of rocks and soils. In addition, industrial wastewater discharges and mining are major sources of metals in fresh waters. Significant amounts also enter surface waters in sewage as well as with atmospheric deposition (Goldman and Horne 1983).

Metals in natural waters can exist in truly dissolved, colloidal and suspended forms. The proportion of these forms varies for different metals and for different water bodies. The toxicity and sedimentation potential of metals change, depending on their forms. The assessment of metal pollution is an important aspect of most water quality assessment programmes. The Global Environment Monitoring System (GEMS/WATER) and the United States Environmental Protection Agency (EPA) consider seven metals as high priority: cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), mercury (Hg), nickel (Ni), and zinc (Zn). However, other elements such as Barium (Ba), Arsenic (As), Beryllium (Be), Antimony (Sb), Cobalt (Co), Thallium (Tl), Molybdenum (Mo), Vanadium (V), Selenium (Se), and Silver (Ag) should also be monitored (US EPA 1993 and Chapman 1997).

The concentration of different metals in waters varies over a wide range (0.1-0.0001 µg/L) at background sites and can rise to concentrations which are dangerous for human health in some water bodies influenced by human activities (US EPA 1993). Typical concentrations in natural water of some of the metals that should be considered in water quality assessments and their significance in water supplies are mentioned in Table 6.

Table 6. Metals concentration and their significance in natural waters

Constituent	Concentration in Natural water ($\mu\text{g/L}$)	Significance in Water Supply
Arsenic (As)	0-1000	Used in industry in some herbicides and pesticides. Lethal in animals above 20 mg/L. Long-term ingestion of 0.21 mg/L reported to be poisonous.
Beryllium (Be)	0.001-1	Highly toxic
Cadmium (Cd)	ND-10	Toxic. Presence may indicate industrial contamination.
Chromium (Cr)	5.8 Median river-0.43 Median public water	Accumulated by vegetation
Cobalt (Co)	ND-1.0	Essential in nutrition in small quantities
Copper (Cu)	10	Essential for nutrition of flora and fauna
Lead (Pb)	1-10	Older plumbing systems contain lead, which may dissolve at low pH. Toxic.
Mercury (Hg)	ND <10	Highly toxic. Sources: pollution from mining, industry or metallurgical works.
Molybdenum (Mo)	0.35 Median river-1.4 Median public water	Accumulated by vegetation.
Nickel (Ni)	10	
Selenium (Se)	0.2	Low solubility. Taken up by vegetation.
Silver (Ag)	0.1-0.3	Has been used as disinfectant.
Vanadium (V)	< 70	May concentrate in vegetation
Zinc (Z)	10	Widely used in industry. Sources: wastes, galvanized pipes, cooling water treatment, etc

ND: No Determined. Source: National Academy of Sciences (1977).

Volatile Organic Compounds

Volatile organic compounds (VOCs) are synthetic organic compounds that include two main categories: (1) fuel-related components, such as benzene, toluene, ethylbenzene, and xylenes (BTEX), and (2) chlorinated solvents, such

as chloroform, trichloroethene (TCE), and tetrachloroethene (PCE). Because of their uses, VOCs are typically associated with urban environments. Many organic compounds enter water bodies as a result of human activities. Examples of VOC sources include leaky underground storage tanks and emissions from automobile exhaust, gasoline/oil storage and transfer, chemical manufacturing, dry cleaners, paint shops and other facilities using solvents (Wentz *et al.* 1998). Considerable quantities of volatile organic compounds (VOCs) are produced in the United States, and their use is ubiquitous. The production of synthetic organic chemicals (many of which are VOCs) has increased by more than an order of magnitude between 1945 and 1985. Volatile organic compounds have significantly different physical, chemical and toxicological properties. These compounds can be important environmental contaminants because many are mobile, persistent, and toxic. In aquatic systems, volatile organic compounds have the ability to accumulate in biological tissues, reaching much higher concentrations in certain aquatic biota. Moreover, VOCs can be very persistent and show little degradation over a period of years (Squillace *et al.* 1999). In drinking water, VOCs may be carcinogenic or otherwise harmful to human health and the aquatic food chain (Wentz *et al.* 1998).

Changes in the physical and chemical characteristics of the water trigger changes in the biotic composition of aquatic systems. Next, critical organisms in fresh water systems indicators of pollution are described and considered.

BIOLOGICAL WATER QUALITY VARIABLES OF STREAMS

The natural bacterial communities of fresh waters are largely responsible for the self-purification processes which biodegrade organic matter. They are peculiarly important to the decomposition of sewage effluents and can be indicative of the presence of high levels of organic matter. However, domestic sewage effluents also add to water bodies large numbers of certain bacterial species from animals' intestines. These bacteria not only may cause several human diseases but also reduce the dissolved oxygen levels in the water affecting other living organisms (Hellawell 1986).

Within the bacteria group, the organisms most commonly used as indicators of fecal pollution are the coliform bacteria. The coliform group comprises all aerobic and facultative anaerobic, gram-negative, nonspore-forming, rod-shaped bacteria. Within the coliform bacteria, the fecal coliforms or heat tolerant coliforms are also used as indicators of fecal pollution. Thus, the presence of coliforms and heat tolerant coliforms has become a common water quality test in streams (Bohn and Buckhouse 1985). The EPA does not have requirements of total coliforms for non-contact water recreation water bodies. For contact water recreation, total coliform must not exceed 10,000 MPN/mL. In relation to fecal coliforms the EPA requires a value below 2,000 MPN/ 100 mL for non-contact water recreation. For water bodies classified as contact water

recreation, the total coliform values should be below 200 MPN/100 mL (San Francisco Bay Regional Water Quality Control Board 1995).

The most common indicator of fecal contamination is the *Escherichia coli*. This bacteria develops in the intestine of humans and warm-blooded animals. Its concentration in human feces amounts to more than 100×10^6 cells per gram of wet weight. However, disease-causing *E. coli* have been isolated from tap water, drinking water sources and streams. The distribution of these organisms is worldwide. Historically, at least in the United States, these organisms reportedly could cause diarrhea and urinary infections (Rheinheimer 1994, Clesceri *et. al* 1999). The EPA does not have a bacteriological criterion for *E. coli* for water non-contact water recreation bodies . The EPA requires a concentration of *E. coli* of less than 235 colonies per 100 mL for water contact recreation bodies (San Francisco Bay Regional Water Quality Control Board 1995).

Another important bacteria group that is analyzed to supplement coliform tests is the enterococcus group, also known as streptococcus. The enterococcus are valuable bacterial indicators for determining the extent of fecal contamination of surface waters. As a rule, this group occurs in lower concentrations than coliforms. Studies at marine and fresh water bathing beaches indicate that swimming-associated gastroenteritis is related directly to the quality of the water and that enterococcus density is the most efficient bacterial indicator of water quality (Rheinheimer 1994). Water quality guidelines based on enterococcal

density have been proposed for recreational waters by the San Francisco Bay Regional Water Quality Control Board . For recreational fresh waters the guideline is 61 enterococci/100 mL while for marine waters is 104/100 mL. Each guideline is based on the geometric mean of at least five samples per 30-days period during the swimming season (San Francisco Bay Regional Water Quality Control Board 1995).

Variations in physical, chemical and biological water quality characteristics caused by pollution could trigger disequilibrium in aquatic systems. The following section provides information about the most important modern stream pollution problems potentially encountered in San Pedro Creek.

SECTION II. MAJOR AND MODERN STREAM POLLUTION PROBLEMS

From 1925 through the early 1970s the paradigm that defined stream water-quality management was represented by the description of dissolved oxygen and bacteria. Over the past 20 years, further studies and observations have broadened our concept of stream water quality. The following section outlines the major pollution problems that must be addressed by modern stream water-quality management schemes.

Nitrification and Ammonia Toxicity

The nitrogen problem in streams is multifaceted. Ammonia can cause oxygen depletion via nitrification¹. If this occurs, one of the byproducts is nitrate, which is itself a pollutant. Further, depending on stream temperature and pH (pH above 9 and at moderate temperatures $\approx 20\text{ }^{\circ}\text{C}$ or $70\text{ }^{\circ}\text{F}$), the ammonia can manifest itself in an un-ionized form ($\text{NH}_3 + \text{H}^+$) which is toxic to aquatic organisms (Rheinheimer 1994).

Eutrophication

Eutrophication refers to the over-stimulation of plant growth due to the discharge of excess nutrients to surface waters. In general, eutrophication studies have focused on estuaries and standing waters (lakes and impoundments) rather than streams. However, as secondary sewage treatment has been used across the United States, more attention is being directed towards the problem of plant growth in rivers. This is especially true for agriculturized and urbanized basins, where nutrient contributions from runoff can be substantial (Margaleff 1996).

In general, stream eutrophication can have a number of deleterious effects on a river. First, the profuse growth of plants decreases water clarity and some species form unsightly scums. Second, certain species of algae cause taste and

¹ The conversion of ammonia to nitrate is collectively called nitrification ($\text{NH}_4^+ + 1.5\text{ O}_2 \rightarrow 2\text{H}^+ + \text{H}_2\text{O} + \text{NO}_2^-$) (Rheinheimer 1994).

odor problems in drinking water. Third, certain blue-green algae can be toxic when consumed by animals. Fourth, eutrophication can alter the species composition of a river ecosystem. Finally, the nutrients can indirectly affect other aspects of stream chemistry. For example, the uptake and release of carbon dioxide by plants can alter the system's pH (Rheinheimer 1994).

The primary controllable nutrients causing eutrophication are nitrogen and phosphorous. In general, an N/P ratio less than 7/10 suggests that nitrogen is limiting. Conversely, higher levels imply that phosphorous will limit plant growth. Streams dominated by wastewater effluents tend to be nitrogen limited. Similarly, estuaries tend to be deficient in nitrogen. In contrast, those systems subject to phosphorous removal and non-point source² input are generally phosphorus limited (Clesceri *et al.* 1989).

Organic Matter

The release into rivers of untreated domestic or industrial wastes high in organic matter results in marked decline of oxygen concentration due to bacteria activity (sometimes resulting in anoxia) and a release of ammonia and nitrite downstream of the effluent input. The effects on the river are directly linked to

² Non-point sources are large or dispersed land areas that pollute water by runoff, surface flow, and deposition from the atmosphere. Examples of non-point source pollution include agricultural, urban, construction, mining and silviculture runoff, septic systems, landfills and spills (Chapman 1997).

the ratio of effluent load to river water discharge. The eventual recovery in oxygen concentrations is enhanced by high water turbulence (Margaleff 1996).

Fecal Contamination

Fecal contamination is still the primary water quality issue in rivers, especially in areas where human and animal wastes are not adequately collected and treated. Although this applies to both rural and urban areas, the situation is probably more critical in fast-growing cities where the population growth rate still far exceeds the rate of development of wastewater collection and treatment facilities. Fecal coliform bacteria can affect human health and the aquatic food chain (Meybeck *et al.* 1989).

Particulate Solids

There are three problems associated with the presence of particulate solids in rivers:

- I) Biotic habitat. The life cycles of many organisms, such as fish, are strongly dependent on the bottom sediments of riverine systems. For example, many species require specific substrate types to successfully reproduce. In addition, a bottom sediment-based food chain supplies nutrition to many organisms.

- II) Toxicant transport and fate. The fate of toxicants is intimately tied to the fate of solids in aquatic systems. In particular, many contaminants concentrate in the bottom sediments of natural waters. Thus contaminants could affect the aquatic system.
- III) Sediment oxygen demand. It has been observed that streams receiving sewage input sometimes experience periods of severe oxygen depletion following short periods of high flow. One explanation is that enriched bottom sediments are re-suspended and induce a short-term oxygen deficit. Changes in oxygen demand can highly affect aquatic organisms and the characteristics of the stream (Mays 1996).

Salinisation

Increased mineral salts in rivers may arise from several sources such as release of mining wastewaters, industrial wastewaters, increase in the evaporation and evapotranspiration in the river basin, domestic wastewater inputs, atmospheric pollution, fertilizer run-off among others. The changes in ionic contents are very often linked to pH changes (Chapman 1997).

Acidification

Acidification can occur in running waters as a result of either direct inputs of acidic wastewater from mining or other industries, and from indirect inputs through acidic atmospheric deposition, mainly as nitric and sulphuric acids resulting mostly from motor exhausts and fossil fuel combustions. In the latter case, acidification of surface waters may only take place if the buffering capacity of the river basin soil is very low. A particular problem associated with acidification is the solubilisation of some metals, particularly of Al^{+3} , when the pH falls below 4.5. the resultant increased metal concentrations can be toxic to fish, and also render the water unsuitable for other uses (Chapman 1997).

Trace Elements

Trace element pollution results from various sources, mostly: i) industrial wastewaters such as mercury from chlor-alkali plants, ii) mining and smelter wastes, such as arsenic and cadmium, iii) urban runoff, particularly lead, iv) agricultural run-off (where copper is still used as pesticide), v) atmospheric deposition, and vi) leaching from solid waste dumps. In surface waters, at a normal pH and redox conditions, most trace elements are readily absorbed onto particulate matter. Therefore, communities such as the benthic and zooplankton could be affected (Meybeck *et al.* 1989).

The major pollution problems previously mentioned have been addressed by researchers who analyzed the water quality of aquatic systems affected by human activities. The following section provides information about stream water quality studies. These studies have taken into account some of the physical, chemical and biological parameters previously considered.

SECTION III. PREVIOUS AND CONCURRENT STREAM WATER QUALITY STUDIES

Water quality studies have been developed in several countries to achieve the best picture of water quality conditions in water bodies. Several studies have analyzed how different land use patterns have affected the water quality in water bodies, providing information about whether waters are meeting designated uses, specific pollutants and sources of pollution, trends, and screen for impairment.

Burt and Day (1977) studied the rainfall and water quality in the area surrounding the Avonmouth industrial complex in the United Kingdom. The authors concluded that the specific electrical conductivity values of rainwater were significantly higher downwind of the complex during storms. The long-term effect of this change in rainfall quality is to produce a marked increase in stream water soluble levels to the north-east of Avonmouth.

Hirose and Kuramoto (1981) evaluated diurnal and seasonal changes in the concentration of eight inorganic ions (NO_3 , NO_2 , NH_4 , PO_4 , K, Na, Ca, and Mg) in four study sites in the rural Kakioka Basin, Japan. Monthly variations in all eight ions were significant. The number of ions showing significant diurnal variations increased with the increase of human activities in the drainage basin.

William L. Graf (1985) evaluated the effects of the Central Arizona Project on the Colorado River Basin in the United States. The author mentioned that wastewater from the Wellton Mohawk Irrigation District increased the salinity of the Colorado River to approximately 6,000 ppm. This affected the fluvial system and depressed agricultural productivity. Mining operations involving heavy metals and radioactive material (copper, vanadium, radium and uranium) had a profound negative impact on the chemistry of the river and threatened wildlife, plants and human health (Graf 1985).

Skovlin (1985) worked in southern Idaho and suggested that the coliform bacteria count in streams is a function of cattle density and their direct access to the streams. At least in this work, runoff from snowmelt appear to have little effect on bacterial concentrations, but that from rainstorms often does (Skovlin 1985).

Thornley and Bos (1985) developed an evaluation of livestock waste management impacts on water quality in a southwestern Ontario watershed in response to frequent downstream beach closures and fish kills. The 90-square-

miles study site contained more than 300 livestock farms. Bacteria (numbers of fecal coliform) and nutrient levels exceeded provincial water guidelines and objectives at most sampling points. Even headwater areas showed bacterial counts and other characteristics comparable to domestic sewage.

Osborne and Wiley (1988) studied the empirical relationship that existed between land use/cover patterns within the Salt Fork watershed (United States) and in-stream nitrate-N and soluble reactive phosphorous concentrations. The results indicated that urbanization, rather than agriculture, was a major factor controlling the soluble reactive phosphorous in-stream concentration throughout the entire year, and was important in explaining the majority of the variance associated with nitrate-N during roughly 50% of the year.

Meybeck *et al.* (1989) reviewed the general trends in the nitrate concentration in surface waters. They note that, while the global median nitrate concentration in surface waters excluding Europe is 0.25 mg /L of NO_3 , the European median level is 4.5 mg /L of NO_3 . The authors attribute this higher nitrate concentration to the greater anthropogenic loading of nitrogen on surface waters in industrialized European countries than in the developing world. Nitrate levels in United Kingdom rivers have risen by 50-400% over the past 20 years. Analyses of water quality data for a number of rivers in the south and east of England have indicated significant and rapid increases in nitrate content to levels

exceeding the European Community/ World Health Organization (WHO) nitrate limit of 11.3 mg /L of NO₃.

Hall *et al.* (1993) compared survival data from *in situ* and *on-site* striped bass (*Morone saxatilis*) larvae tests conducted in the Nantocoke River, Choptank River, upper Chesapeake Bay and Potomac River of the Chesapeake Bay watershed in United States from 1984 to 1990 and discussed the possible effects of contaminants and water quality conditions on survival of striped bass pro-larvae in these habitats. Acidic conditions (pH < 6.5) were reported to reduce survival of pro-larvae in the Nantocoke River, although these conditions were not present in every year. Acidic conditions and trace elements (aluminum, cadmium, copper and zinc) in the Choptank River were also suspected as factors contributing to mortality of pro-larvae during *in situ* tests. Survival of striped bass pro-larvae was generally greater in the upper Chesapeake Bay when compared with the other habitats. Low salinity, high electrical conductivity, and lack of toxic contaminants were suspected as contributing to the high survival. Low survival of pro-larvae was reported during all 4 years of testing in the Potomac river. Sudden reductions in temperature and presence of various trace metals (aluminum, cadmium, copper, lead and zinc) were suspected as contributing to the low survival in this system. Results from this 7-year study suggested that environmentally realistic acidic conditions, contaminants (primarily trace metals) and low temperatures can reduce survival of striped bass pro-larvae.

May *et al.* (1997) studied the effects of urbanization on small streams in the Puget Sound Lowland ecoregion (Washington) in the United States. Their results reported that physical, chemical and biological characteristics of streams change with increasing urbanization. They reported that physical and biological measures generally changed most rapidly during the initial phase of all urbanization processes as the measure of total impervious area (%TIA) exceeded the 5-10% range. As urbanization progressed, the rate of degradation of habitat and biological integrity usually became more constant. There was also direct evidence that the altered watershed hydrological regime was the leading cause of the overall changes in physical habitat conditions. The authors also pointed out that once urbanization increased above the 50% level, most pollutant concentrations rose rapidly, and it is likely that the role of water and sediment chemical water quality became more important biologically. In addition to urbanization level, a key determinant of biological integrity appears to be the quantity and quality of the riparian zone available to buffer the stream ecosystem, in some measures, from negative influences in the watershed. Moreover, the authors mentioned that urbanization affected the benthic community and the composition of the salmon community.

Tufford *et al.* (1998) developed multiple regression models relating land use to instream concentrations of total nitrogen (TOTN) and total phosphorous (TOTP) in eight, low-order watersheds on the coastal plain of South Carolina.

The models for TOTN (r^2 from 0.25-0.63) explained more variability of stream nutrient concentrations than those for TOTP (r^2 from 0.16-0.39). Seasonal models were generally significant and demonstrate that the seasonal profile of stream nutrient concentrations is dependent on the mosaic of land uses in a specific sub-basin.

Vaisanen et al. (1998) evaluated stream water quality in the border areas of Finland, Norway, and Russia. They determined the impacts of smelting industries at Nikel and Zapoljarnij. The results showed considerably higher contents of K (Potassium), Ca (Calcium), Mg (Magnesium), SO_4 (Sulphates), Na (Sodium), heavy metals and electrical conductivity in the samples close to Nikel and Zapoljarnij smelters than those sites more distant from polluting sources. Chemical effects of high emissions of Ni, Cu and SO_2 on stream water quality from Nikel and Zapoljarnij smelters were clearly seen near the sources of emissions.

Currently in the United States, especially in California, peoples' concern about the effect of urban development and human activities upon fresh water habitats has prompted water quality studies for urban streams. Examples include studies being carried out on the San Lorenzo River and Walnut Creek in Santa Cruz. Parameters such as total suspended particles, turbidity, pH, nitrates, dissolved oxygen, conductivity, stream flow and benthic macroinvertebrates are being tested and analyzed (Conrad per. comm. 2000).

In San Mateo County, a chemical monitoring program is being developed for several creeks that are home to endangered species such as steelhead trout (*Oncorhynchus mykiss*) and Coho Salmon (*Oncorhynchus kisutch*), including San Gregorio, Whitehouse and La Calera creeks. Temperature, pH, dissolved oxygen, turbidity, phosphorus, nitrates and conductivity are being considered (Tahaxson, per. Comm. 2000, San Gregorio Environmental Resource Center 2000).

For San Pedro Creek there has been interest in developing water quality analysis due to its importance as habitat for steelhead trout and to the recreational opportunities the creek offers to the community. The steelhead depend on the stream for clean gravel for spawning habitat, a healthy estuary for the young, as well as clean water to support the aquatic insects that they eat (San Gregorio Environmental Resource Center 2000). In 1998, Paul Jones from the Environmental Protection Agency (EPA) started to test total and fecal coliform, *Escherichia coli* and Enterococcus bacteria groups along the creek. Also, the San Mateo County started bacteriological analyses along the creek. In addition, two residents of Pacifica (Bernard and Eulalia Halloran) conducted an independent study of the quality of the water in San Pedro Creek. The Hallorans' data were analyzed by the City and County of San Francisco wastewater treatment experts. For years there have been stories and anecdotes about surfers and waders in the creek getting sick, and a reduction in the steelhead

trout population. The San Mateo County, EPA and the Hallorans' data showed that the creek's bacteria levels were higher than the permissible levels for recreational purposes for most of the sampling period (more than 1000 units of total coliform bacteria /100 ml, and 200 units of fecal coliform/100 ml). Since then, permanent signs have been posted cautioning people against letting children play in the creek. A growing awareness of pollution in urban creeks throughout the Bay Area has resulted in similar signs at most creeks emptying into the ocean (Larsen 1999).

On January 1999, the Environmental Protection Agency laboratory in Richmond performed acute toxicity tests³ using *Ceriodaphnia dubia* (a zooplankton organism) on samples collected in San Pedro Creek. The toxicity tests were performed on grab samples collected at four locations: North Fork, Main Stem above the North Fork, at Capistrano bridge and at the Beach. The results indicated that there were no statistically significant adverse effects from the samples on the invertebrate. However, the North Fork sample caused some decrease in survival (USEPA 1999a). On March of the same year, the EPA performed chronic toxicity tests⁴ using *Pimephales promelas* (fathead minnows fish). The toxicity tests were performed using water from the same four locations previously mentioned. The results indicate that there were no statistically

³ A relatively short-term test, usually defined as occurring within 4 days for fish and macroinvertebrates and shorter times (2 days) for smaller animals (Clesceri *et al.* 1989).

⁴ Long-term test (7 days) that may be related to changes in appetite, growth, metabolism, reproduction and even death or mutations (Clesceri *et al.* 1989).

significant adverse effects from the samples on the larval fathead minnow. There was a lower survival and lower biomass of fish in the North Fork and Beach samples, but the differences from control were not statistically significant (USEPA 1999a).

The concepts and related studies reviewed in this chapter provide critical information to support the methods used in this research and to explain the results presented in next chapter. Also, this literature review encompassed the key ideas that are needed to address the questions set for the study: What is the water quality of San Pedro Creek Watershed? and how does the water quality of San Pedro Creek changes during different seasons and along the creek? The next chapter outlines the methods considered to pursue the research questions.

CHAPTER IV

METHODS

The present research was carried out throughout the year 2000. Sampling took place every Monday from 7:30 a.m. to 12:30 p.m. during the following periods: January 23 - February 28, April 24 - May 22, July 17 - August 14, October 30 - November 27. The sampling periods were chosen to evaluate the water quality of San Pedro creek considering the seasonal variability.

Description of Sampling Sites

Water samples were taken at seven sites along the creek: 1) Oddstad bridge, 2) North Fork, 3) Linda Mar bridge, 4) Peralta bridge, 5) the creek mouth, 6) in front of the creek mouth, and 7) the parking lot located in front of Pacifica State Beach (Figure 6). The sites were selected to determine whether cumulative changes occur in water quality along the creek (variability over space). Oddstad bridge is located at the northwestern part of the Middle Fork (Figure 6). The water in this point comes from the San Pedro Valley County Park (Middle Fork) (Figure 7). The North Fork sampling site (Figure 6 and 8) is

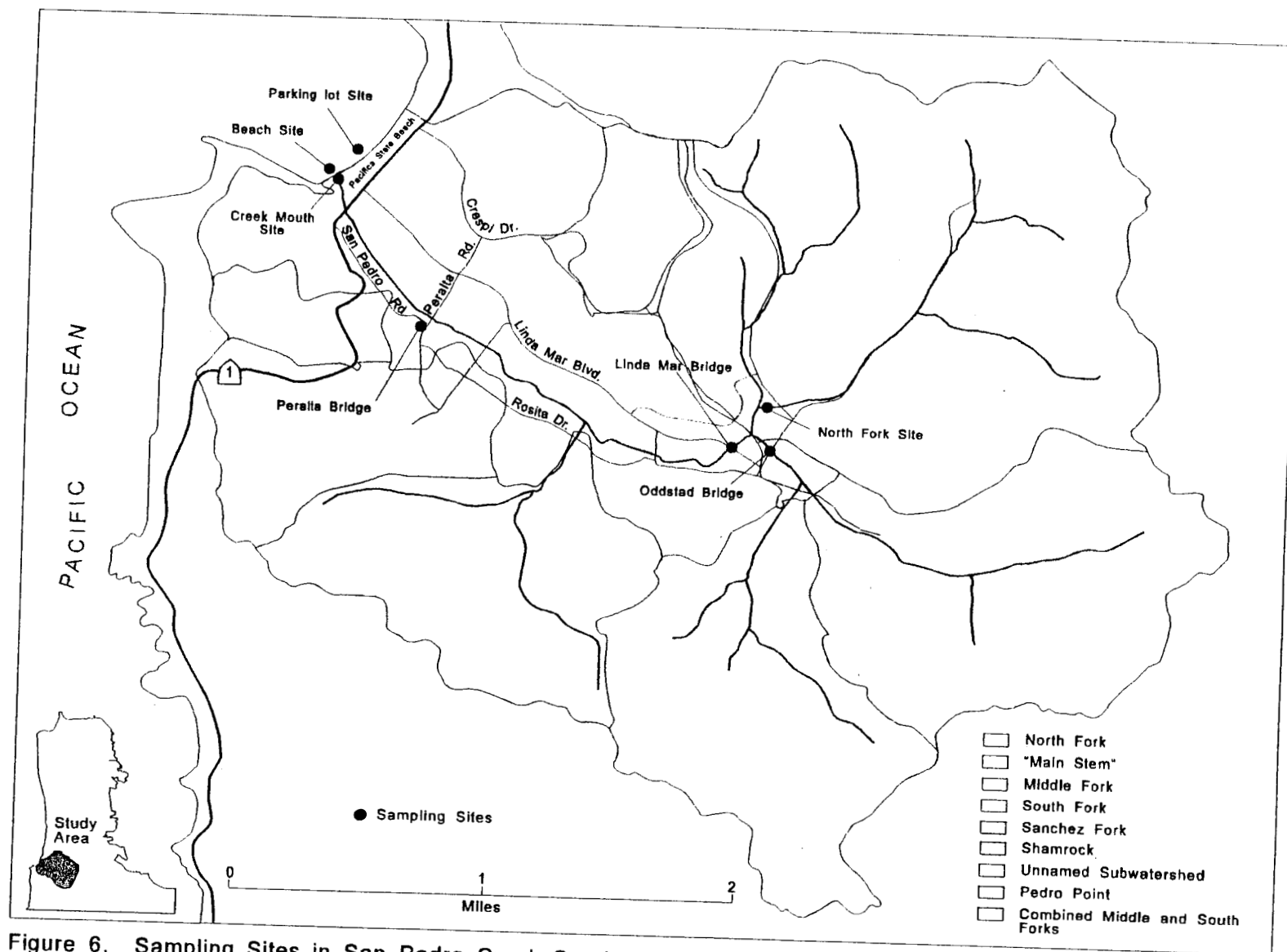


Figure 6. Sampling Sites in San Pedro Creek (San Pedro Creek Watershed Coalition 1999)



Figure 7. The Oddstad sampling site



Figure 8. The North Fork sampling site

located at the southern part of the North Fork. The water at this point comes from the culvert outflow that collects water from the North Fork. After the North Fork sampling site, the other sampling points are located along the main stem of the creek which flows northwesterly toward the Pacific Ocean (Figure 6). Linda Mar bridge (Figure 9) is located near the eastern end of Linda Mar Boulevard. Peralta bridge (Figure 10) is located between Peralta and San Pedro road. Finally, the creek mouth (Figure 11) is located in front of Pacifica State Beach, while the other two sampling sites are located in the ocean surface zone at the State Beach: in front of the creek mouth and the parking lot (Figures 6, 12 and 13).

Sampling Procedure

Data Field Collection

One data sheet was designed to facilitate the collection of data in the field (Appendix 1). Information about physical environmental characteristics of each sampling site as well as parameters such as pH, dissolved oxygen and conductivity was included in the field data sheet. Moreover, weather conditions of the day before the sampling day, and the day of the sampling were recorded in the field collection data sheet. The weather information for Pacifica was obtained from the weather channel website at



Figure 9. Linda Mar sampling site



Figure 10. Peralta sampling site



Figure 11. Creek mouth or Outlet sampling site

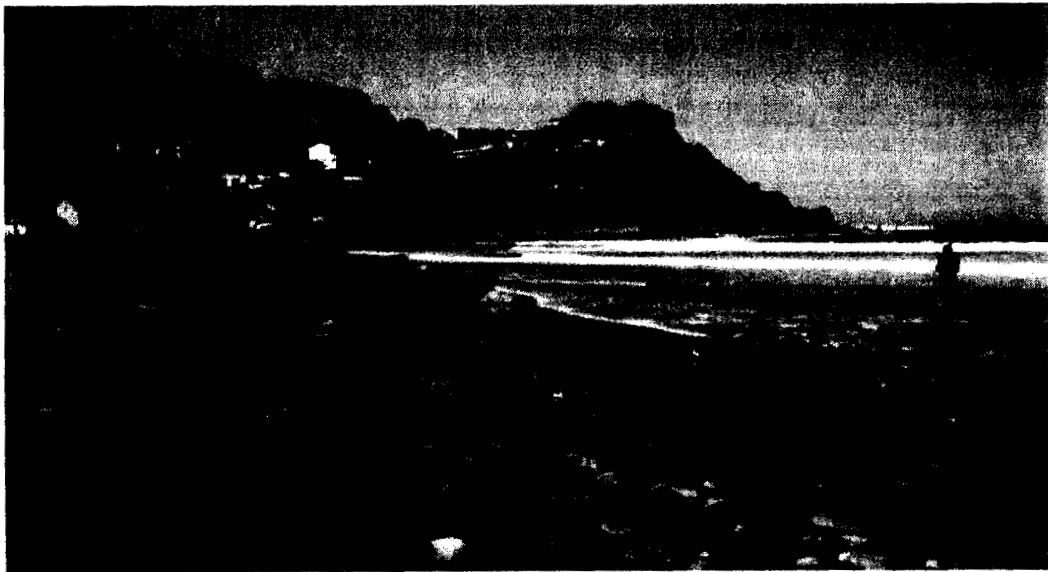


Figure 12. Beach sampling site



Figure 13. Parking lot sampling site

<http://www.weather.com/weather/us/zips/94127.html>. Parameters such as general conditions, wind, temperature (Hi and Low temperatures), dew point, relative humidity, visibility and pressure were considered. Information about tide conditions and rainfall was obtained from the Pacifica Tribune.

Collecting Samples

Prior to the sampling process, weather conditions were checked. Also, the pH-meter and conductivity-meter were calibrated using the 4.0 and 7.0 buffer solutions and the Chloride potassium standard solution respectively.

Upon arriving at the sample site, general site conditions including time, rain/no rain, organic litter, water color and runoff conditions, were observed and

recorded in the field collection data sheet. At each sampling site, parameters such as pH, air and water temperature, and electrical conductivity were recorded in the field by the researcher. The pH, electrical conductivity and water temperature were measured using the Fisher Scientific accumet portable AP50. The air temperature was obtained using an air thermometer. The dissolved oxygen (DO) was measured using the dissolved oxygen meter YSI Models 54 ARC and 54 ABP; DO was not measured in front of the creek mouth and the parking lot due to their location in the ocean.

Three water samples were taken at each sampling site. Two samples, each of 100 mL, were collected for bacteriological analyses conducted by the EPA Laboratory at Richmond and the San Mateo County Health Department. The other samples, each of 300 mL, were collected for turbidity, alkalinity and hardness analyses developed by the researcher at La Calera Creek Treatment Plant. The EPA analyzed bacteriological parameters such as total coliform, *Escherichia coli* and Enterococcus. Enterococcus were analyzed in the parking lot and in front of the creek mouth sampling sites following the EPA protocol for salt water bacteriological analyses. The San Mateo County Health Department analyzed total and fecal coliforms for each of the seven sampling sites.

One-liter samples were taken to be analyzed by the Sequoia laboratory. Analyses such as metals (Mercury, Antimony, Arsenic, Barium, Beryllium, Cadmium, Chromium, Cobalt, Copper, Lead, Molybdenum, Nickel, Selenium,

Silver, Thallium, Vanadium and Zinc), phosphorus, nitrogen ammonia, nitrates, nitrites, total suspended particles, and volatile organic compounds (Benzene, 2-Butane, Carbon tetrachloride, Chlorobenzene, Chloroform, 1,2-Dichloroethane, 1,1-Dichloroethane, Tetrachloroethene, Trichloroethene, Vinyl chloride, 1,2-Dichloroethane-d4, Toluene-d8) were taken at the Oddstad bridge and North Fork. These sampling sites were chosen considering the fact that the North Fork is the most urbanized area in the watershed. Oddstad bridge provides a good “control” point because the water at that point comes from San Pedro Valley Park.

The physical, chemical and biological parameters analyzed in this research were chosen considering previous and concurrent land use activities in the watershed and recommendations found in the EPA Volunteer Stream Monitoring Methods Manual (1997).

The water samples were collected following the EPA protocol. All the samples were collected in the main current, facing upstream (Figure 14). To collect water samples using the screw-cap bottles, the following procedure was used (Figure 15): 1) the cap from the bottle was removed without touching the inside of the bottle or cap. If the inside of the bottle was accidentally touched, another bottle was used; 2) the bottle was turned into the current and scooped in an upstream direction. The water was collected 8 to 12 inches beneath the



Figures 14. Position to Take a Water Samples (USEPA 1997).

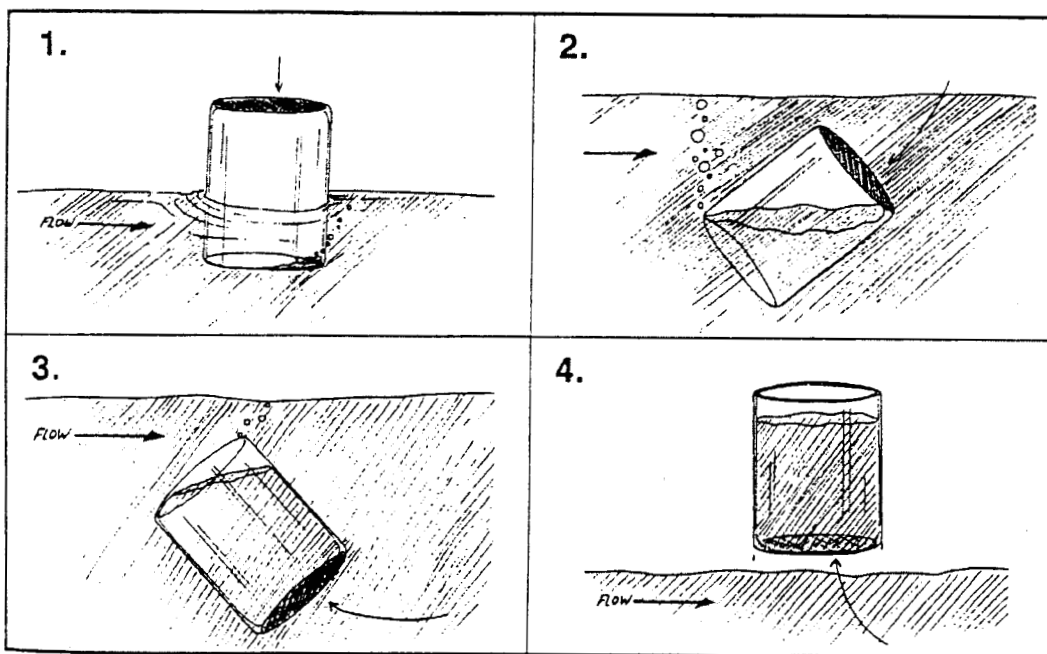


Figure 15. Steps to Take a Water Sample (USEPA 1997).

surface or mid-way between the surface and the bottom if the stream was shallow. 3) The bottle was turned underwater into the current and away from the researcher. In slow-moving stream conditions, the bottle was pushed underneath the surface and away from the researcher in an upstream direction. 4) 100 ml of water were collected leaving 1-inch air space. After the water samples were collected, each bottle was labeled including information such as sampling site, date and time following the requirements of each of the labs. Afterwards, the bottles were placed in coolers with cold packs to preserve the samples (USEPA 1997).

Measuring Discharge

The stream discharge was measured at the Peralta bridge sampling site using a Swoffer model 2100 flow meter along a cross sectional profile. The stream stretch selected in Peralta bridge is straight (no bends), and does not contain an area of slow water such as a pool (USEPA 1997). These conditions are recommended to properly measure and calculate stream discharge. To measure and calculate discharge, a cross-sectional area⁵ was determined for each flow width interval (Figure 16). Average velocity for each interval was measured using the flow meter. The information was collected in a field

⁵ Cross-sectional area is the product of stream width multiplied by average water depth (USEPA 1997)

collection data sheet (Appendix 2). The discharge at each interval was calculated by multiplying the width, the depth, and

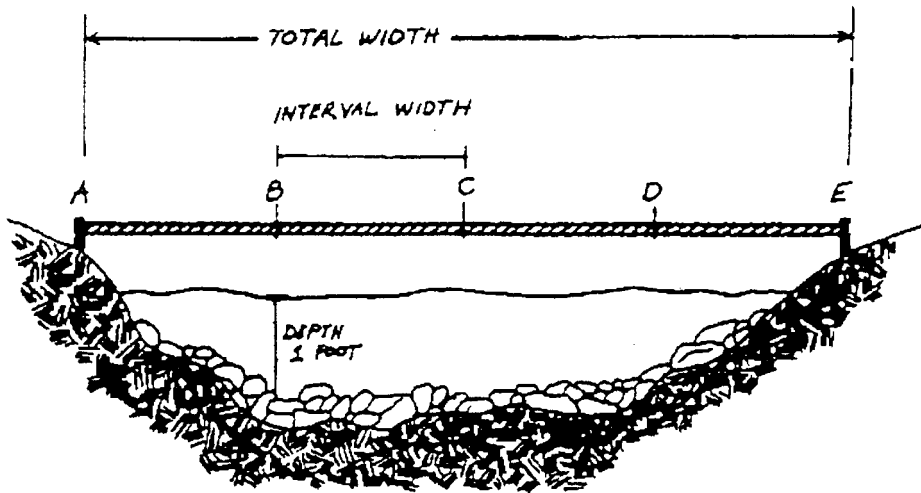


Figure 16. Cross Section View to Measure Discharge (USEPA 1997).

the velocity. The total discharge was calculated by adding the discharges at each interval reported in cubic feet per second (cfs). To determine the water level, the distance from Peralta bridge to the water surface was measured using a 25 feet Stanley Power lock II metallic tape.

Sample Analyses

The bacteriological analysis carried out by the EPA laboratories at Richmond used the Colilert⁶ and Enteroalert⁷ methods. The Multiple Tube Fermentation method⁸ was used by the San Mateo County Health Department to analyze total and fecal coliforms, and *Escherichia coli*. The Sequoia Laboratories used methods standardized by the EPA.

Turbidity, alkalinity and hardness were measured by the researcher. A data collection sheet was designed to report the data (Appendix 3). Turbidity was analyzed using the MONITEK TA1 Nephelometer owned by the La Calera Creek treatment plant. Alkalinity was analyzed using the method suggested by Barnes (1964) described as following: Calibrate the pH meter with pH 4 buffer. Take 100 ml of the water sample and insert the pH probe. Run in HCl (approx 0.001 N) until the pH meter shows a stable reading of between pH 3 & 4. Read final pH and amount of acid used. Finally, alkalinity was calculated by using the following formula:

$$\text{Alk (m-eq/L)} = \frac{V_a C_a - H_f (V_a + V_s)}{V_s} \times 1000$$

⁶ 24-hours method used to analyze total and fecal coliform as well as *Escherichia coli*. 1ml of the water sample and 99 ml of distilled water that contains nutrients indicators for the bacteria groups are poured into a tray. Afterwards the tray is place in incubator at 44.5 °C (112 °F) (IDEXX 1996).

⁷ 18-hours method used to analyze enterococcus bacteria (IDEXX 1996).

⁸ Method that uses a series of dilutions of the water samples which are incubated for 24 to 48 hours at 35 +/- 0.5 °C (95 °F) (Clesceri *et al.* 1995).

Where,

Va = vol. acid used (mL).

Hf = final H+ conc. of solution (final pH).

Vs = sample volume (mL).

Ca = conc. acid used (eq/L).

Finally, hardness was analyzed following the EDTA Titrimetric Method (Clesceri *et al.* 1995). In the EDTA method, 25 mL of the water sample are diluted to 50 mL with distilled water. Then, 2 mL of buffer solution and two drops of the hardness indicator are added. Finally, a titration with the EDTA titrant solution is developed until the sample gets a blue-end point. The formula used to calculate hardness is the following:

$$\text{Hardness (mg CaCO}_3\text{ /L)} = \frac{A \times 1000}{\text{mL of sample}}$$

where A is the total amount of titrate used in mL.

As mentioned in Chapter III, freshwater aquatic life criteria for certain metals are expressed as a function of hardness and/or water quality characteristics that are usually correlated with hardness can reduce or increase the toxicities of some metals. To derive freshwater aquatic life criteria for metals in San Pedro Creek two formulas recommended by the EPA were used (USEPA 2000):

1.- Criteria Maximum Concentration (CMC) equals the highest concentration of a pollutant to which aquatic life can be exposed for a short period of time without deleterious effects. The formula is the following:

$$CMC = WER \times (\text{Acute Conversion Factor}) \times (\exp (m_A(\ln(\text{hardness})) + b_A)))$$

2.- Criteria Continuous Concentration (CCC) equals the highest concentration of a pollutant to which aquatic life can be exposed for an extended period of time (4 days) without deleterious effects. The formula is the following:

$$CCC = WER \times (\text{Acute Conversion Factor}) \times (\exp (m_c(\ln(\text{hardness})) + b_c)))$$

Where WER is the Water Effect ratio, m_A , m_c , b_A , and b_c are factors for calculating metals criteria specific each metal. WER is 1.0 for hardnesses over 400 mg/L as CaCO_3 ; alternatively, the WER and actual hardness of the surface water may be used (USEPA 2000).

A sample handling and analysis protocol for San Pedro Creek summarizing the methods used in this study was created by the researcher to be used in future research (Appendix 4).

Data Analysis

The Statistical Package for Social Sciences (SPSS version 10.0) was used for processing and analyzing the data collected in this study. Descriptive statistics such as the mean, its 95% confidence interval and standard deviation were calculated to describe the data collected by season and by sampling site.

In addition, descriptive statistics were considered when comparing the Regional Board, the EPA and the water quality standards reported in literature to the results collected in this study. The Pearson correlation and linear regressions were calculated to analyze associations and variations between variables. Graphics were used to describe, summarize and simplify data showing the information visually. The results, analyses and discussions are presented in the following Chapters.

CHAPTER V

RESULTS

The results are organized as follows: First, figures of the average of each physical, chemical and biological parameter collected at the seven sampling sites throughout the four sampling periods are shown. Then, descriptive statistical analyses for the results recorded by season and by sampling site are calculated and compared. Finally, Pearson correlations and linear regression analyses are considered. These analyses helped 1) to determine whether or not there are significant differences between the parameters analyzed in San Pedro Creek Watershed during the four sampling periods (seasonal variability); 2) to compare in-stream physical, chemical and biological characteristics of the watershed to the San Francisco Water Quality Control Board, EPA or literature standards, and; 3) to determine whether cumulative changes occur in water quality along the creek (variability over space).

Rainfall and Air Temperature

General precipitation levels for San Pedro Creek watershed during the sampling periods were obtained from the Pacifica Tribune newspaper (Pacifica Tribune 2000). These values as well as field conditions during each sampling period are shown in Appendix 5. Table 7 shows average rainfall reported during

the five consecutive Mondays of each sampling period at San Pedro Creek watershed. As expected, most rainfall was reported during winter (1.10 inches) and fall (0.08 inches) seasons. No rain was reported during the spring and summer sampling periods.

Table 7. Average rainfall of the five consecutive Mondays during the four sampling periods in San Pedro Creek watershed

Sampling Period	Average Rainfall (inches)
January-February	1.10
April-May	0.0
August-July	0.0
October-November	0.08

Air temperature had seasonal changes throughout the sampling year (Table 8). The highest values were recorded during late spring, ranging from 13.8 to 17.1 °C (56.8 – 62.8 °F) and July-August ranging from 14.7 to 16.3 °C (58.5 – 61.3 °F). The lowest values were recorded during winter, ranging from 12.8 to 14 °C (55 – 57.2 °F), and during fall ranging from 11.6 to 14.3 °C (55.8 – 57.74 °F).

Air temperature also varied among sampling sites. Overall, Oddstad presented the lowest air temperature followed by the North Fork, Linda Mar, and Peralta (Table 8). The warmest air temperature values were recorded at the outlet, beach and parking lot sites. Table 8 shows the average air temperature values (°C) calculated for each sampling site throughout the sampling year.

Appendix 5 shows the air temperature values recorded during the year of the study.

Table 8. Average of air temperature values (°C) for each sampling site during the four sampling periods

Sampling site	Jan-Feb 00	April-May 00	July-Aug. 00	Oct.-Nov. 00
Oddstad	12.8	13.8	15.1	12.4
North Fork	14.0	15.7	15.1	11.6
Linda Mar	12.9	15.5	14.7	12.5
Peralta	13.7	15.8	15.4	12.3
Outlet	14.0	18.2	16.3	13.6
Beach	14.0	17.1	16.3	14.0
Parking lot	14.0	17.1	15.6	14.3

PHYSICAL WATER QUALITY VARIABLES

Temperature

During the four sampling periods in the year 2000, water temperature ranged between 11.5 and 15.8 °C (52.7 and 60.4 °F) among the seven sampling sites along the watershed (Figure 17). Table 9 shows the mean water temperature values calculated for each season. The mean water temperature during winter was 12.3 °C (54.2 °F). In late spring and summer, water temperature increased from 13.6 °C (56.5 °F) to 14.4 °C (57.9 °F). In the October- November period water temperature decreased to 12.8 °C (55 °F).

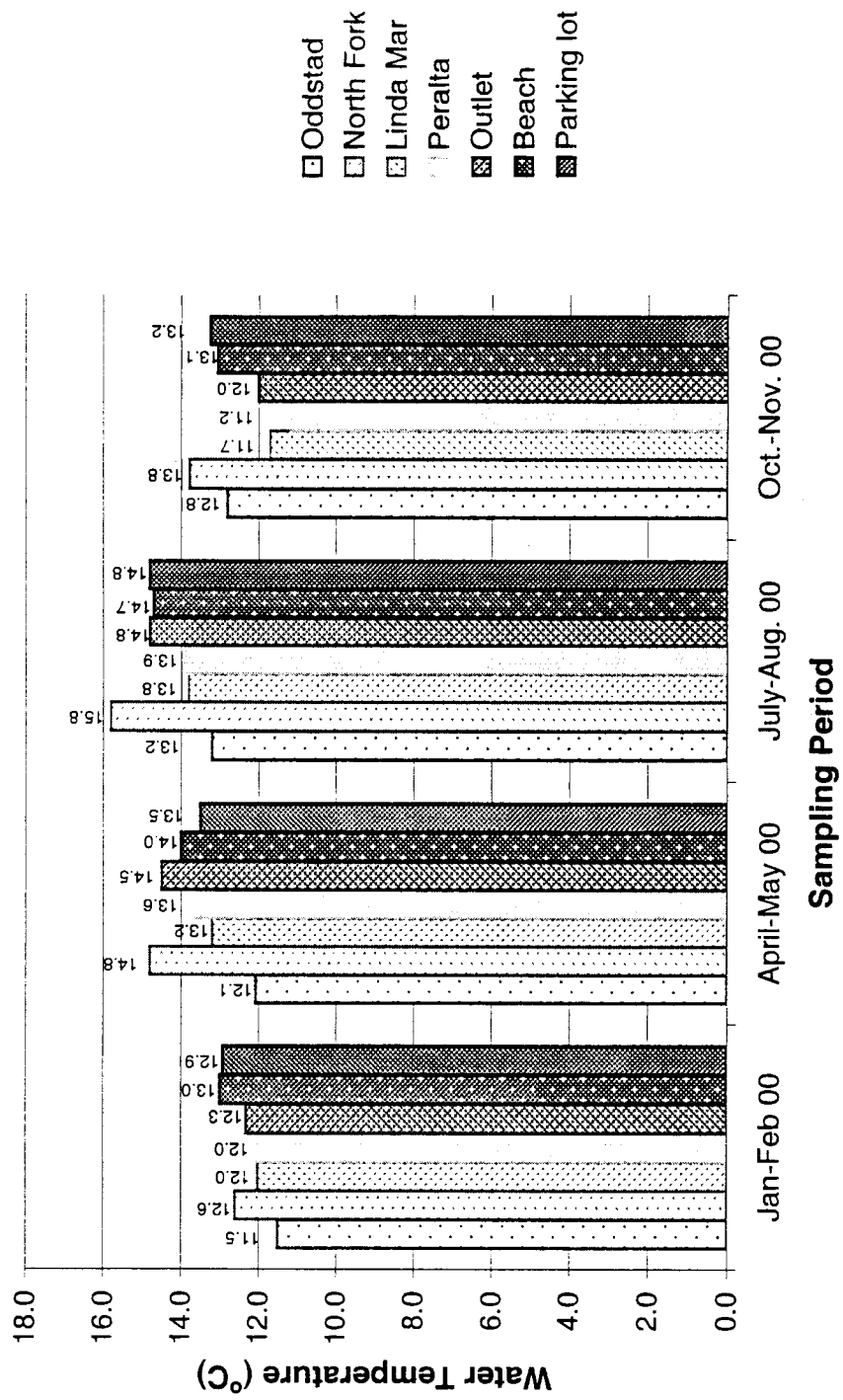


Figure 17. San Pedro Creek mean water temperature values for each of the sampling periods

Table 9. Descriptive statistics for the sampling periods

Parameter	Seasons											
	Winter			Spring			Summer			Fall		
	Mean	95% C.I.	SD	Mean	95% C.I.	SD	Mean	95% C.I.	SD	Mean	95% C.I.	SD
Water temperature	12.3	12,1 12,5	0.7	13.6	13,3 14,0	1.1	14.4	14,1 14,7	1.0	12.8	11,7 12,8	1.7
Total suspended solids	NA	NA	NA	16.2	- 20,4 52,8	51.2	NA	NA	NA	NA	NA	NA
Turbidity	90.4	39,2 141,4	131.7	12.9	2,35 3,45	1.6	2.2	1,64 2,72	1.6	3.1	2,27 3,93	2.4
Stream discharge	61.8	-78,9 202,6	88.4	3.8	2,85 4,82	0.8	1.0	0,83 1,25	0.2	1.1	0,0076 2,15	0.9
pH	7.7	7,62 7,84	0.3	8.1	8,07 8,19	0.2	8.2	8,15 8,28	0.2	8.1	8,03 8,12	0.1
Alkalinity	2.5	1,61 3,42	1.3	3.1	2,56 3,72	1.4	3.1	2,40 3,75	1.6	4.1	3,22 4,89	2.0
Hardness	NA	NA	NA	NA	NA	NA	718.8	568,6 869,13	364.0	602.2	527,2 677,4	182.1
Conductivity	345.2	293,7 396,6	124.5	409.3	355,0 463,7	131.6	419.2	352,9 485,5	157.0	396.1	326,7 465,4	167.9
Dissolved oxygen	10.6	10,4 10,68	0.3	10.0	9,82 10,16	0.4	9.9	9,72 10,07	0.4	10.03	9,82 10,24	0.5
Nitrate	NA	NA	NA	6.9	6,43 7,36	0.6	NA	NA	NA	NA	NA	NA
Nitrite	NA	NA	NA	0.0	0.0	0.0	NA	NA	NA	NA	NA	NA
Nitrogen ammonia	NA	NA	NA	0.1	0,0246 0,2180	0.1	NA	NA	NA	NA	NA	NA

95% C. I.: 95% confidence interval for mean (lower and upper bound)

SD: Standard deviation

NA: No data available

Continue

Table 9. Descriptive statistics for the sampling periods

Parameter	Seasons											
	Winter			Spring			Summer			Fall		
	Mean	95% C.I.	SD	Mean	95% C.I.	SD	Mean	95% C.I.	SD	Mean	95% C.I.	SD
Phosphorus	NA	NA	NA	0.023	0,0128 0,0338	0.015	NA	NA	NA	NA	NA	NA
Zinc	NA	NA	NA	0.005	0,000322 0,00985	0.007	NA	NA	NA	NA	NA	NA
Silver	NA	NA	NA	0.006	-0,00762 0,0197	0.019	NA	NA	NA	NA	NA	NA
Total coliforms	6855.7	1232,4 12478,9	6080.1	7690.7	-118,5 15499,9	8443.9	9462.3	-729,6 19654,1	11020.1	5328.2	1321,5 9334,9	4332.3
Fecal coliforms	443.7	143,09 744,33	325.0	822.7	156,04 1489,3	720.8	581.0	101,7 1061,9	519.0	327.8	-6,81 662,5	361.9
<i>Escherichia coli</i>	547.0	-6,37 1100,3	598.3	556.5	-43,0 1156,1	648.3	793.8	-171,3 1759,0	1043.6	339.8	-47,4 727,12	419.0
Enterococcus	40.0	-277,6 357,6	35.4	26.0	-136,18 194,18	18.4	23.0	-65,9 111,9	9.9	66.0	-569,3 701,3	70.7

95% C. I.: 95% confidence interval for mean (lower and upper bound)

SD: Standard deviation

NA: No data available

Mean water temperature values were also calculated for each sampling site (Table 10). The North Fork site had the highest mean water temperature value (14.2 °C (57.5 °F)) followed by the beach and parking lot (13.6 °C (56.5 °F)), the outlet (13.4 °C (56.1 °F)), Linda Mar and Peralta sites (12.7 °C (54.9°F)). The lowest mean water temperature value was reported at Oddstad (11.9 °C (53.5 °F)) site.

Water temperature mean for each sampling period and each sampling site were compared to the Regional Board water temperature standard. As mentioned in Chapter III, this standard says that water temperature differences cannot exceed more than 5 C° (9 F°) along the watershed throughout the year and during each sampling period (San Francisco Bay Regional Water Quality Control Board 1995). The highest water temperature difference along the creek during each sampling period was not higher than 2 C° (3.6 F°). Therefore, the Regional Board standard was achieved. In addition the water temperature optimum range for aquatic organisms including the steelhead trout (between 14 and 16 °C (57.8 and 60.8°F)) (Magaud *et al.* 1997, Rowland 1998) was also achieved.

Water temperature values recorded during the five consecutive Mondays of each sampling period at each sampling site are shown in Appendix 6.

Table 10. Descriptive statistics by sampling site

Parameter	Sampling site											
	Oddstad			North Fork			Linda Mar			Peralta		
	Mean	95% C.I.	SD	Mean	95% C.I.	SD	Mean	95% C.I.	SD	Mean	95% C.I.	SD
Water temperature	12.0	11.3 12.5	1.2	14.2	13.5 14.9	1.5	12.7	12.06 13.298	1.3	12.7	11.96 13.4	1.5
Total suspended solids	32.4	-57.5 122.35	72.4	NA	NA	NA	NA	NA	NA	NA	NA	NA
Turbidity	24.1	-18.09 66.21	87.5	12.3	0.0492 24.51	25.4	20.3	-12.19 52.7	67.3	24.1	-14.7 63.01	80.7
Stream discharge	NA	NA	NA	NA	NA	NA	NA	NA	NA	14.6	-6.61 35.7	44.0
pH	7.8	7.70 7.95	0.3	8.0	7.89 8.04	0.2	8.1	7.96 8.18	0.2	8.2	8.06 8.32	0.3
Alkalinity	1.8	1.44 2.11	0.6	6.0	5.24 6.75	1.5	3.1	2.60 3.51	0.9	3.0	2.54 3.40	0.8
Hardness	573.6	350 797.1	312.5	857.6	600.3 1114.8	359.7	473.6	779.9 610.8	214.1	586.8	467.3 706.2	166.9
Conductivity	241.7	213.5 270.06	58.6	606.7	542.1 671.2	137.8	357.6	323.8 391.4	72.2	366.6	334.98 398.31	67.7
Dissolved oxygen	10.4	10.2 10.57	0.4	9.7	9.52 9.93	0.4	10.0	10.36 10.17	0.4	10.3	10.06 10.45	0.4
Nitrate	6.4	5.89 6.93	0.4	7.4	6.88 7.90	0.4	NA	NA	NA	NA	NA	NA
Nitrite	0.0	0.0	0.0	0.0	0.0	0.0	NA	NA	NA	NA	NA	NA
Nitrogen ammonia	NA	NA	NA	0.2	0.1609 0.3250	0.1	NA	NA	NA	NA	NA	NA

95% C. I: 95% confidence interval for mean (lower and upper bound)

SD: Standard deviation

NA: No data available

Continue

Table 10. Descriptive statistics by sampling site

Parameter	Sampling site											
	Oddstad			North Fork			Linda Mar			Peralta		
	Mean	95% C.I.	SD	Mean	95% C.I.	SD	Mean	95% C.I.	SD	Mean	95% C.I.	SD
Phosphorus	0.017	-2.38E-03 0.0317	0.016	0.029	0.0142 0.0441	0.012	NA	NA	NA	NA	NA	NA
Zinc	NA	NA	NA	0.0	2.83E-03 0.01754	0.006	NA	NA	NA	NA	NA	NA
Silver	0.012	-0.021 0.045	0.027	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total coliforms	1487.5	822.8 2152.15	417.6	17434.2	-1833.3 36701.8	12108.7	8148.5	342.15 15954.8	4905.8	9358.7	7831.2 10886.2	959.9
Fecal coliforms	74.5	37.55 111.4	23.2	841.1	-69.23 1751.23	572.03	613	-213.57 1457.57	530.7	1135.0	541.8 1728.15	372.8
<i>Escherichia coli</i>	57.8	-5.29 120.79	39.6	409.5	15.27 803.72	247.7	227.3	127.6 326.83	62.6	1315.8	92.96 2538.53	768.5
Enterococcus	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

95% C. I.: 95% confidence interval for mean (lower and upper bound)

SD: Standard deviation

NA: No data available

Continue

Table 10. Descriptive statistics by sampling site

Parameter	Sampling site								
	Outlet			Beach			Parking lot		
	Mean	95% C.I.	SD	Mean	95% C.I.	SD	Mean	95% C.I.	SD
Water temperature	13.4	12.65 14.1	1.6	13.6	13.13 14.11	1.0	13.6	13.12 14.08	1.0
Total suspended solids	NA	NA	NA	NA	NA	NA	NA	NA	NA
Turbidity	23.8	-15.22 62.7	80.9	22.4	-11.31 56.18	70.0	21.3	-11.29 53.93	67.7
Stream discharge	NA	NA	NA	NA	NA	NA	NA	NA	NA
pH	8.2	8.04 8.28	0.2	8.1	8.06 8.222	0.2	8.2	8.06 8.24	0.2
Alkalinity	2.8	2.36 3.22	0.8	NA	NA	NA	NA	NA	NA
Hardness	658.0	430.5 885.4	317.9	NA	NA	NA	NA	NA	NA
Conductivity	380.7	344.4 416.9	77.5	NA	NA	NA	NA	NA	NA
Dissolved oxygen	9.9	9.68 10.15	0.5	NA	NA	NA	NA	NA	NA
Nitrate	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nitrite	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nitrogen ammonia	NA	NA	NA	NA	NA	NA	NA	NA	NA

95% C. I: 95% confidence interval for mean (lower and upper bound)

SD: Standard deviation

NA: No data available

Continue

Table 10. Descriptive statistics by sampling site

Parameter	Sampling site								
	Outlet			Beach			Parking lot		
	Mean	95% C.I.	SD	Mean	95% C.I.	SD	Mean	95% C.I.	SD
Phosphorus									
Zinc									
Silver									
Total coliforms	12176.2	5508.8 18843.6	4190.1	2495.5	-2719.9 7710.98	3277.6	239.0	-305.9 783.945	342.5
Fecal coliforms	885.3	407.24 1363.25	300.4	162.5	-6.945 331.94	106.5	97.0	-122.8 316.8	19082.0
<i>Escherichia coli</i>	1552.0	488.67 2615.32	668.2	313.0	-382.19 1008.19	436.9	40.0	-34.53 114.5	46.8
Enterococcus				50.8	-20.66 122.16	44.9	28.3	-10.73 67.23	24.5

95% C. I: 95% confidence interval for mean (lower and upper bound)

SD: Standard deviation

NA: No data available

Totals Suspended Solids

Due to budget limitations, the total suspended solids were only analyzed for late spring. Oddstad and the North Fork sites were selected to evaluate this chemical parameter based upon the differences in land-use categories between the two sites as mentioned in Chapter II. The average of total suspended solid values calculated for Oddstad was 32.4 mg/L. No values were reported for the North Fork.

Total suspended solids were only recorded at the Oddstad site with a mean value of 32.4 mg/L. When comparing the total suspended solids mean to the reporting limit for aquatic organisms of approximately 80 mg/L (Rowland 1998), the limit during the April-May sampling period was achieved. Each total suspended value recorded during late spring is shown in Appendix 7.

Turbidity

Turbidity values during the study year ranged between 0.6 and 110 NTU (nephelometric units) (Figure 18). The highest mean values were reported in winter (90.4 NTU). The lowest value was recorded at the North Fork (12.3 NTU) followed by Linda Mar (20.3 NTU) and the outlet sites (23.8 NTU). A mean value of 24.1 NTU was calculated at Oddstad and Peralta sites (Table 10).

As mentioned in Chapter III, there are no numerical turbidity standards reported by either the EPA or the Regional Board. In the case of aquatic

organisms, they prefer values below 80 NTU (Rowland 1998). Comparing the turbidity means to the turbidity levels preferred by aquatic organisms, the only sampling period that exceeded the 80 NTU value was the winter season. On the other hand, Oddstad, Peralta, the outlet and the sampling sites located in the ocean surface exceeded the turbidity values for aquatic organisms throughout the sampling year. Turbidity values recorded during the study year are shown in Appendix 8.

Stream Discharge and Water Level

The stream discharge and water level were measured at the Peralta Bridge as described in Chapter IV. Figure 19 and Table 9 show the discharge and water level values measured during the sampling period. Winter had the highest discharge (61.8 cfs or 1.75cms), and the highest water level (3.2 feet or 0.97 meters). Then, discharge and water level decreased in spring (3.8 cfs or 0.11 cms – 1.8 feet or 0.52 meters) and summer (1.03 cfs or 0.029 cms –1.6 feet or 0.49 meters). Finally, discharge and water level slightly increased in fall

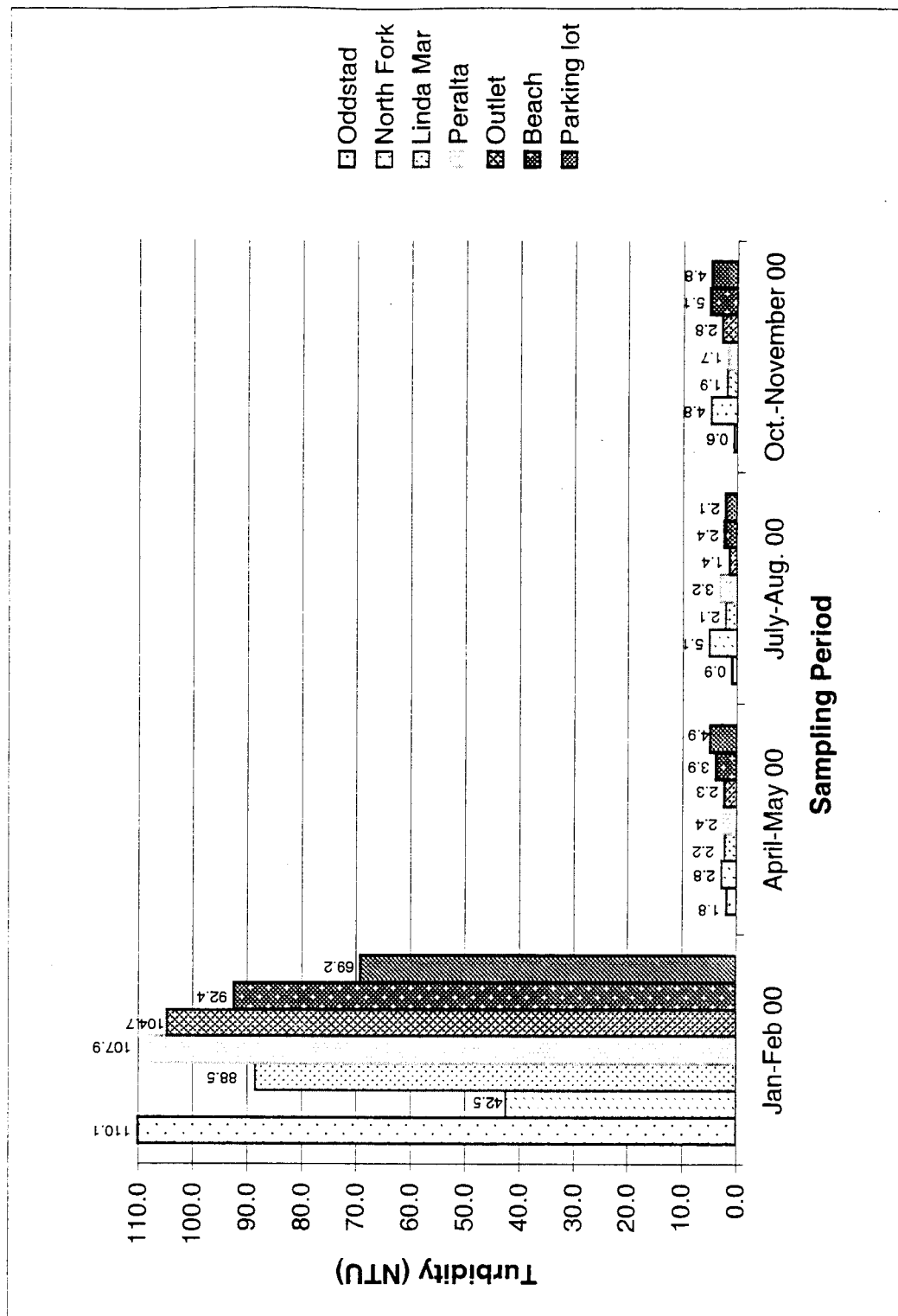


Figure 18. San Pedro Creek mean turbidity values for each of the sampling periods

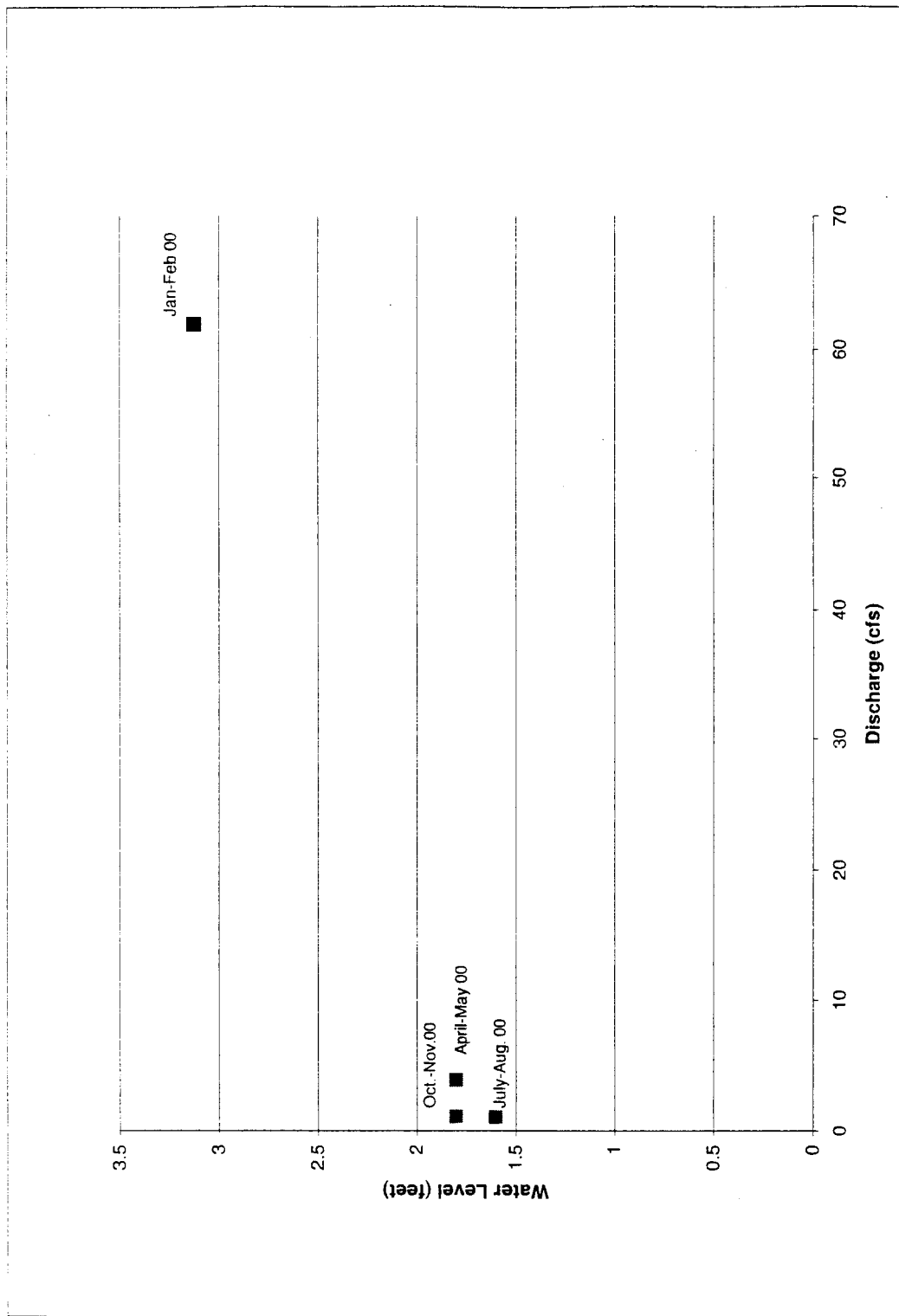


Figure 19. Mean discharge and water level at Peralta Bridge for each of the sampling periods

representing 1.07 cfs (0.030cms) and 1.8 feet (0.55 meters), respectively. The detailed information collected throughout the year is shown in Appendix 9.

CHEMICAL WATER QUALITY VARIABLES

pH

Throughout the sampling year, pH along the watershed ranged between 7.5 and 8.4 (Figure 20). The mean pH increased from winter (7.73) to spring (8.1), and summer (8.2), and then decreased in fall (8.07) (Table 9).

pH also varied among sampling sites. Overall, the pH pattern was to increase from Oddstad (7.8) North Fork (8.0), Linda Mar (8.1) to Peralta (8.2). pH values in Peralta, the outlet, the beach and the parking lot had similar values, between 8.1 and 8.2, as shown in Table 10. This pattern is more noticeable when looking at the pH values recorded during the five consecutive Mondays of each of the four sampling periods (Figure 21). The values recorded at Oddstad were statistically different when comparing to the other sites along the creek (Table 10).

pH mean values of each sampling period (Table 9) and site (Table 10) were compared to the Regional Board and aquatic organisms pH standard range (6.5-8.5). Neither of the pH values was under or above the pH standard range.

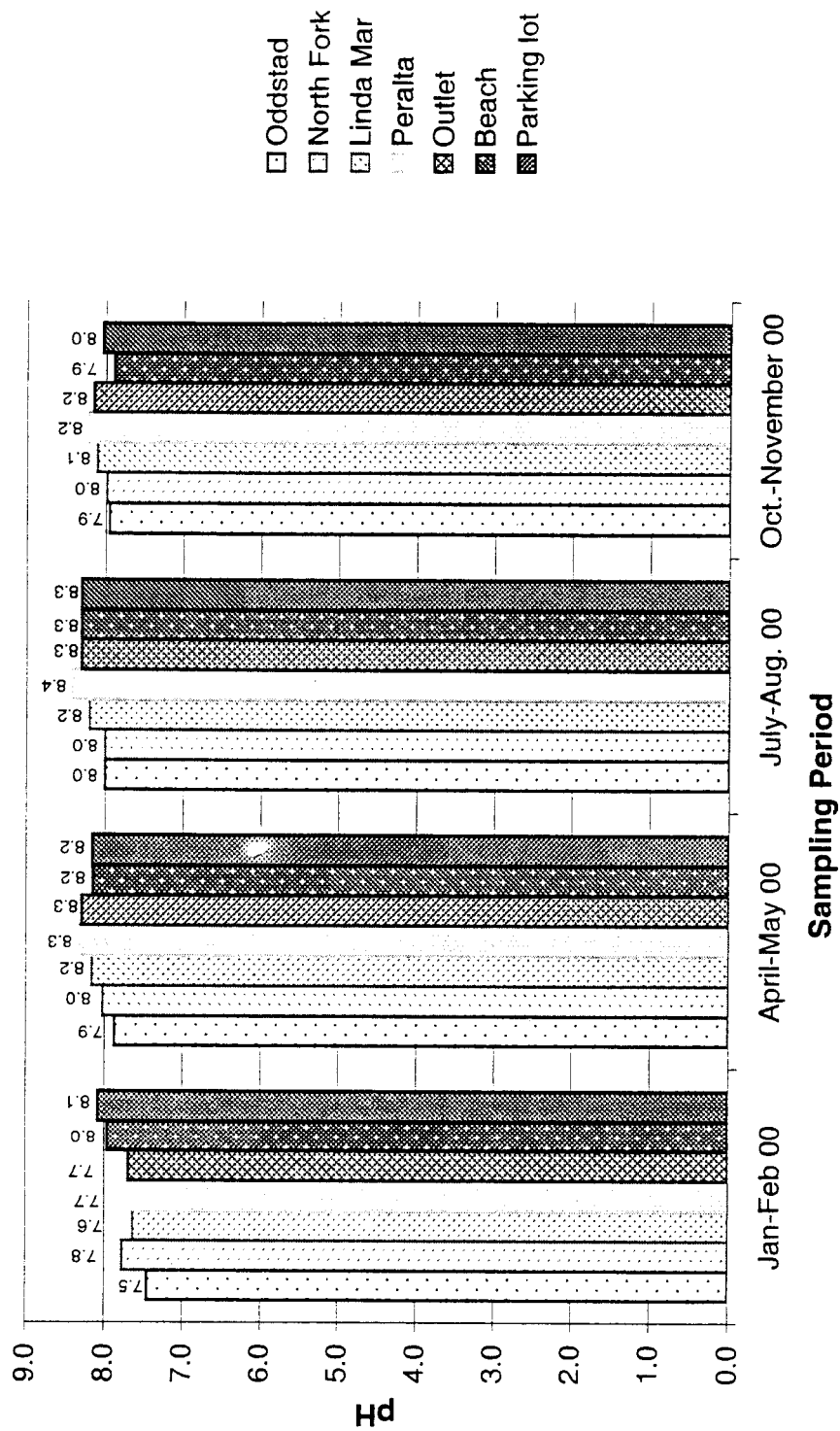


Figure 20. San Pedro Creek pH mean values for each of the sampling periods

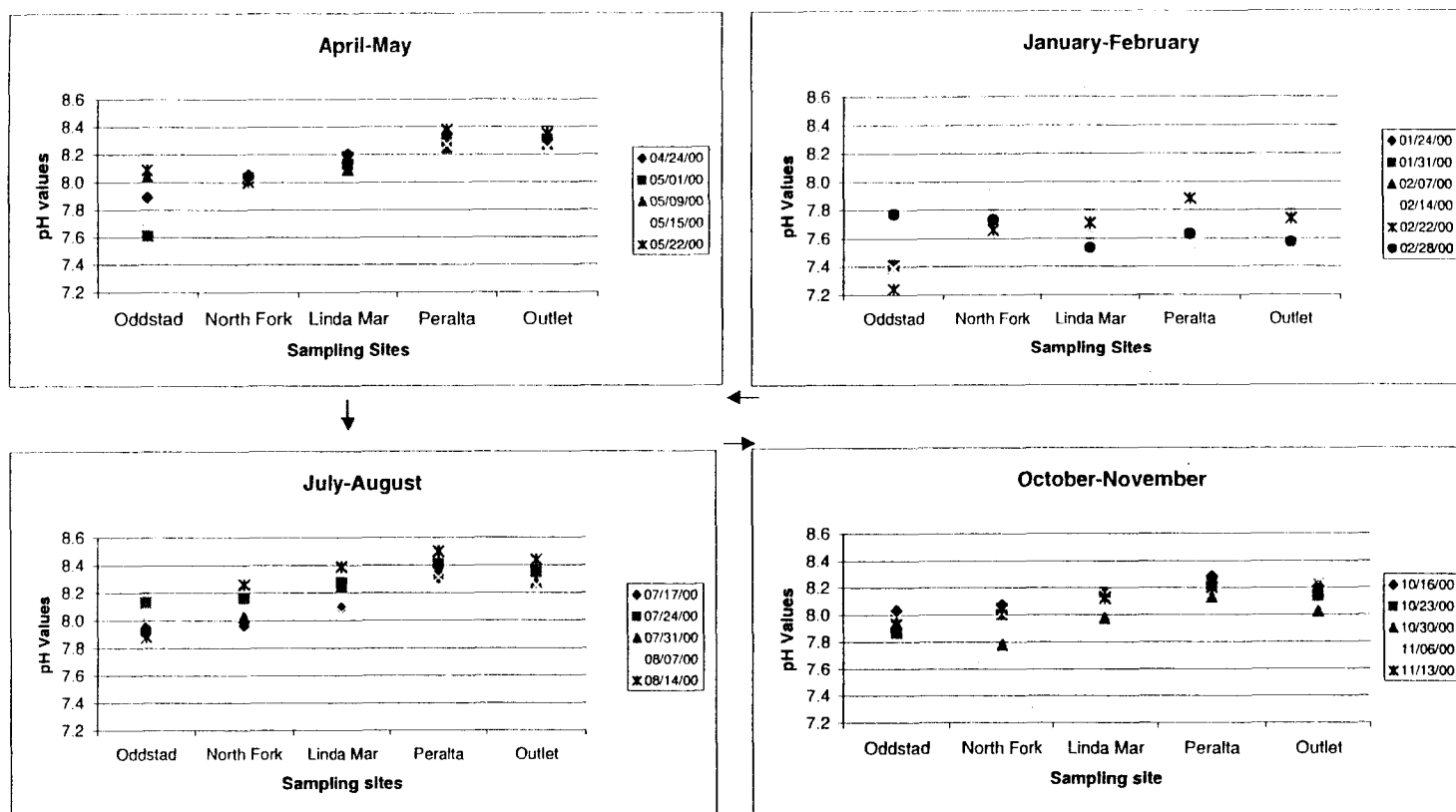


Figure 21. San Pedro Creek ph values recorded during the five consecutive Mondays in each sampling period.

Therefore, the standard was achieved during the sampling year in all of the sampling sites. Appendix 6 shows the pH values collected at each sampling site during the study.

Alkalinity

Sampling sites located at the ocean surface (beach and parking lot) were not tested for alkalinity due to their difference in water chemical composition from the sites located along the creek. Alkalinity, a measure of the capacity of water to neutralize acids, along the watershed during the sampling year ranged between 1.26 m-eq/L (63 mg/L CaCO_3) and 7.34 m-eq/L (367 mg/L CaCO_3) (Figure 22). The mean alkalinity value during wintertime was 2.52 m-eq/L (126 mg/L CaCO_3). In late spring, summer, and fall alkalinity values increased being 3.15 m-eq/L (157.5 mg/L CaCO_3), 3.1 m-eq/L (155 mg/L CaCO_3), and 4.1 m-eq/L (205 mg/L CaCO_3), respectively (Table 9). Although there was an increase in the alkalinity values during the sampling year, there were not significant differences among the mean values reported during the four sampling periods.

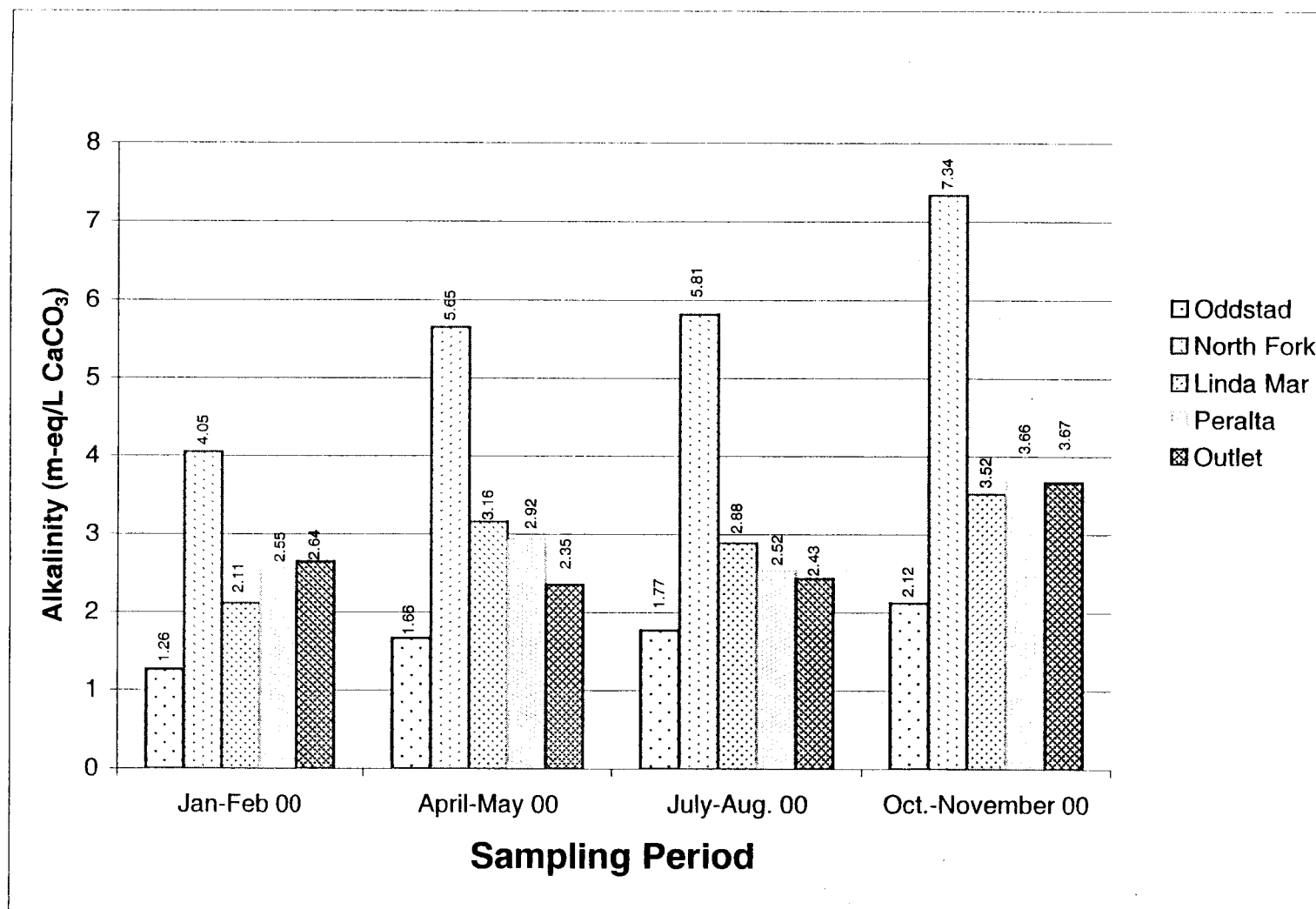


Figure 22. San Pedro Creek mean alkalinity values for each of the sampling periods

In relation to the sampling sites (Table 10), the highest mean value was recorded at the North Fork (6.0 m-eq/L, or 300 mg/L CaCO₃). The lowest value was reported at Oddstad (1.78 m-eq/L, or 89 mg/L CaCO₃). Linda Mar, Peralta and the outlet had similar alkalinity values 3.1 m-eq/L (155 mg/L CaCO₃), 2.97 m-eq/L (148.5 mg/L CaCO₃), and 2.8 m-eq/L (140 mg/L CaCO₃), respectively.

Comparing the alkalinity mean values recorded for the sampling periods (Table 9) to the typical fresh water values reported in the literature (150 mg/L CaCO₃) (Mays 1996), spring (3.1 m-eq/L (155 mg/L CaCO₃), summer (3.1 m-eq/L (155 mg/L CaCO₃), and fall (4.1 m-eq/L (205 mg/L CaCO₃) exceeded this value. The typical fresh water value was also exceeded in the North Fork (6.0 m-eq/L (300 mg/L CaCO₃) and Linda Mar (3.1 m-eq/L (155 mg/L CaCO₃) sites (Table 10). In addition, when comparing the alkalinity values reported during the sampling year, and at each sampling site, to the alkalinity tolerance range for aquatic organisms (10-400 mg/L CaCO₃) (Rowland 1998), all values were within the tolerance range. Detailed alkalinity values recorded during the sampling year are shown in Appendix 10.

Hardness

Due to budget limitations, hardness was only analyzed for the July-August and October-November sampling periods. In addition, sampling sites located at

the ocean surface water (beach and parking lot) were not tested for hardness due to limitations of the EDTA titration method with salt water.

The hardness values reported for San Pedro Creek ranged between 477.6 and 964.8 mg/L of CaCO_3 (Figure 23). The hardness mean value in summer was 719 mg/L of CaCO_3 and in fall was 602.2 mg/L of CaCO_3 (Table 9).

As shown in Figure 23, hardness tended to increase from Oddstad (574 mg/L of CaCO_3) to the North Fork (858 mg/L of CaCO_3), to decrease at Linda Mar (474 mg/L of CaCO_3), and finally, to remain similar at Peralta and the outlet sites (587 and 658 mg/L of CaCO_3 , respectively).

As mentioned in Chapter III, typical fresh water hardness values range between 1-1,000 mg/L of CaCO_3 (Mays 1996, Rowland 1998). San Pedro Creek hardness values were within this range in all the season and at all sampling sites during the research year (Tables 9 and 10). On the other hand, when comparing the hardness criteria for coldwater species (10-400 mg/L of CaCO_3) to the values reported in San Pedro Creek, in all season and at all sampling sites this criterion was exceeded. Appendix 11 shows the hardness values reported in each of the two sampling periods.

Electrical Conductivity

Throughout the study, electrical conductivity (EC), a measure of the ability of water to pass an electrical current, along the watershed ranged between 214

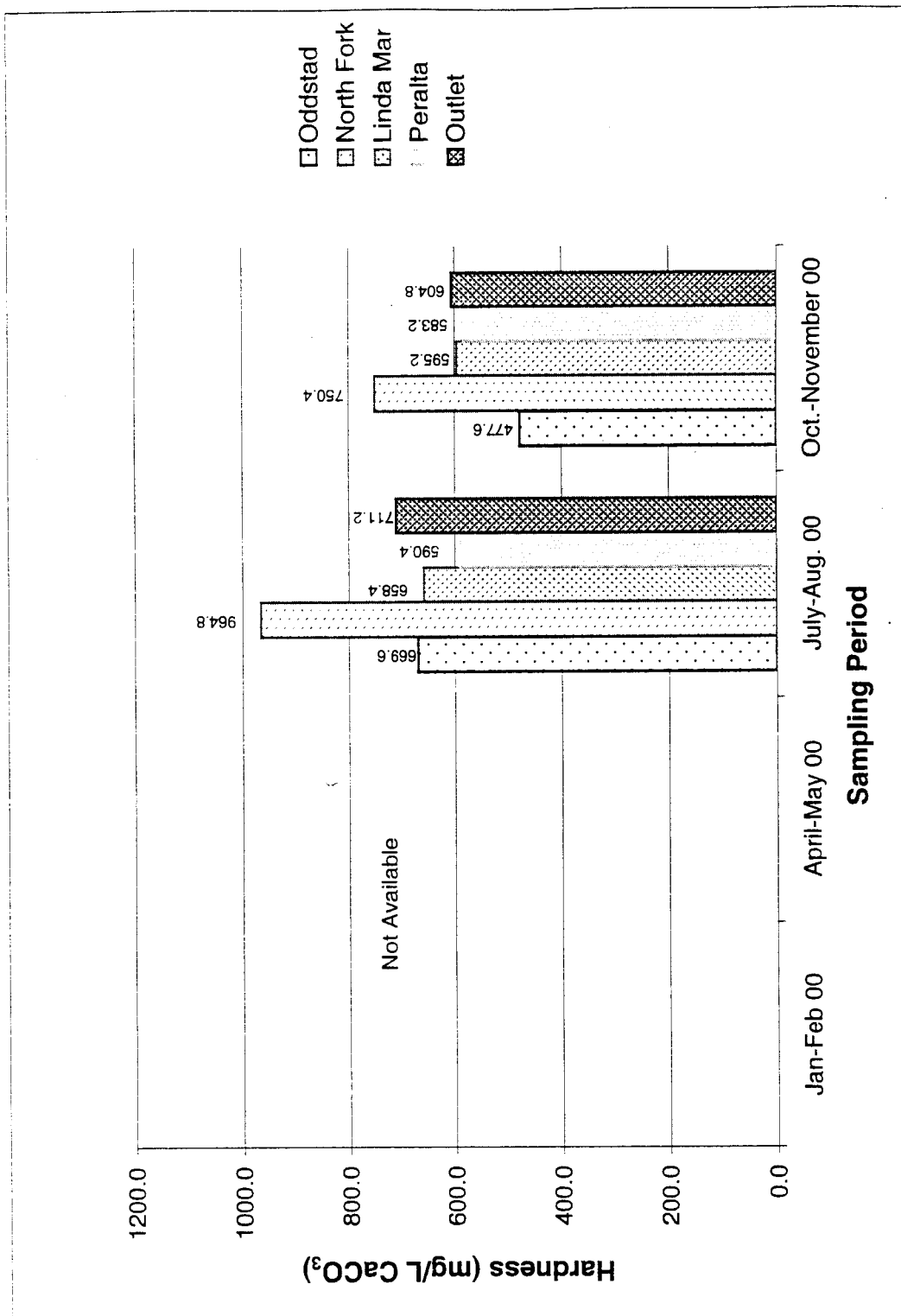


Figure 23. San Pedro Creek mean hardness values for each of the sampling periods

and 680 $\mu\text{S}/\text{cm}$ (Figure 24). Comparing the four sampling periods, EC increased from winter (345 $\mu\text{S}/\text{cm}$) to spring (409.3 $\mu\text{S}/\text{cm}$) and summer (419 $\mu\text{S}/\text{cm}$), and then decreased in fall (396 $\mu\text{S}/\text{cm}$) (Table 9).

The highest mean EC value was reported at the North Fork (606 $\mu\text{S}/\text{cm}$) and the lowest value was recorded at Oddstad (242 $\mu\text{S}/\text{cm}$). In addition, similar values were reported at Linda Mar, Peralta and the outlet sites (357, 366 and 381 $\mu\text{S}/\text{cm}$, respectively) (Table 10).

Comparing the EC mean values recorded seasonally and at each sampling site to the typical fresh water values (10-1,000 $\mu\text{S}/\text{cm}$) (Chapman 1997), statistics showed that EC was within the range reported in the literature (Table 9 and 10).

Because of a difference in chemical composition between fresh and salt water, EC values recorded at the beach and parking lot sites were analyzed in a different figure (Figure 25). Overall, at the parking lot the EC values were higher than at the beach site. In both sampling sites the values ranged between 22,840 and 29,080 $\mu\text{S}/\text{cm}$. EC values recorded during each sampling period at each sampling site are shown in Appendix 6.

Dissolved Oxygen

Dissolved oxygen as described in Chapter IV, was not measured at the two ocean sites, the beach and the parking lot. San Pedro Creek's dissolved

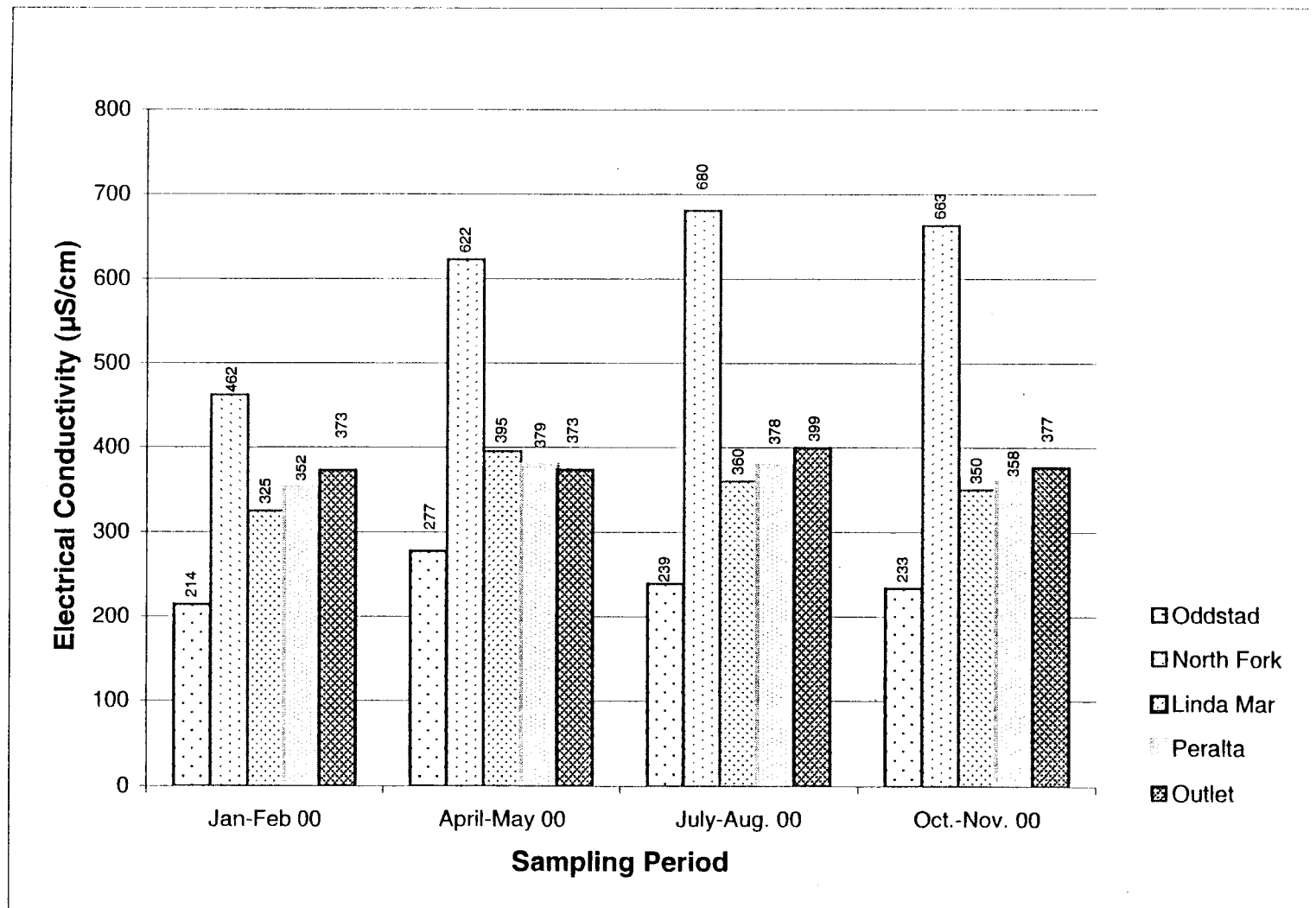


Figure 24. San Pedro Creek mean electrical conductivity values for each of the sampling periods

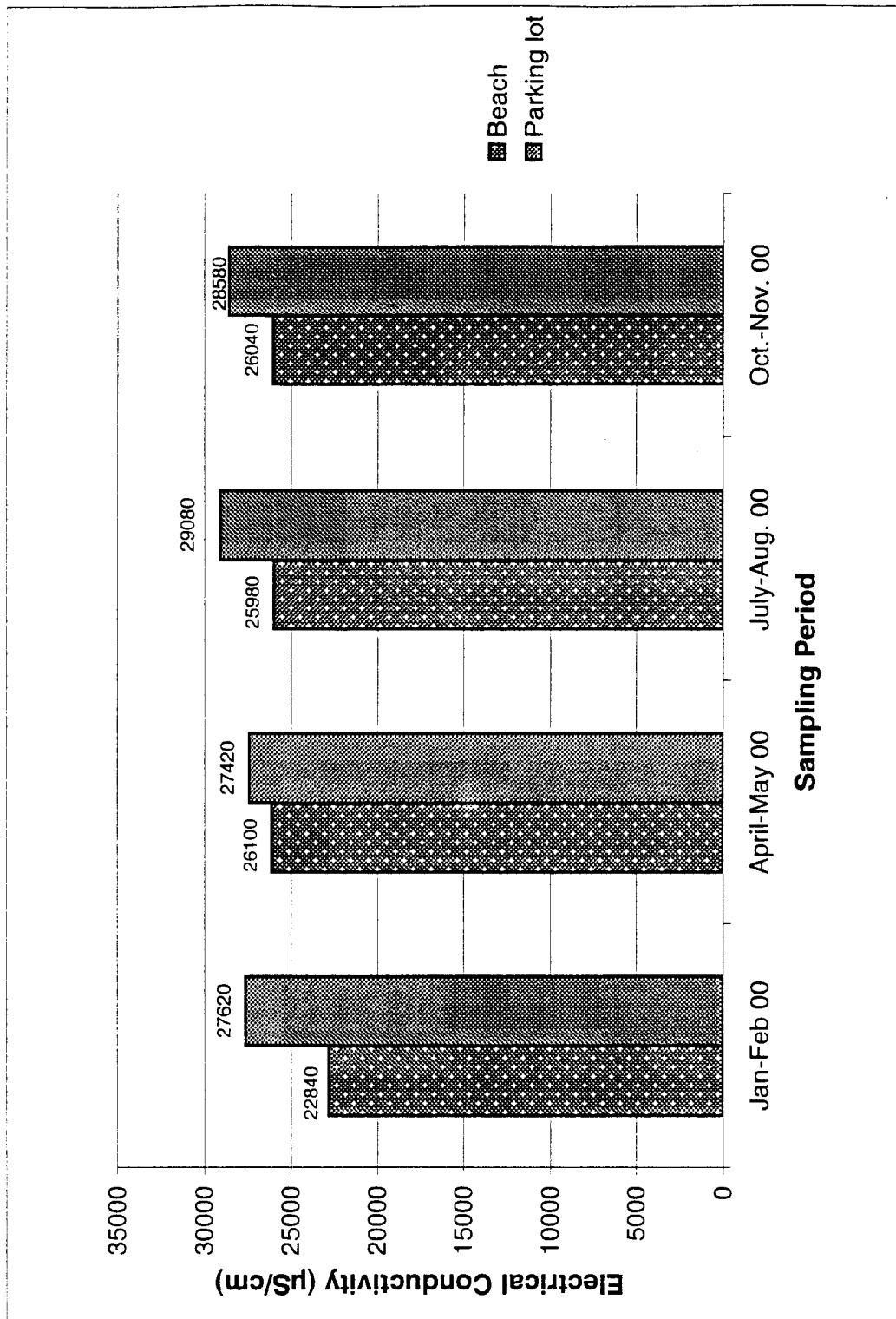


Figure 25. Mean conductivity values for the Beach and Parking lot sampling sites during each of the sampling periods

oxygen values ranged between 9.4 and 10.8 mg/L (Figure 26). The highest mean values along the watershed throughout the year were recorded in winter (10.6 mg/L) and fall (10.03 mg/L). The lowest values were registered in late spring and summer (9.99 and 9.90 mg/L, respectively) (Table 9). Appendix 6 shows the dissolved oxygen values recorded throughout the sampling year.

Among sampling sites, the highest dissolved oxygen values were reported at Oddstad ranging from 10.2 to 10.8 mg/L and the lowest range values were recorded at the North Fork (9.4-10.3 mg/L) and outlet sites (9.8-10.3 mg/L). At the other sampling sites, dissolved oxygen range from 10.0 to 10.7 mg/L. Thus, there is a pattern in the dissolved oxygen of decreasing from Oddstad to the North Fork, increasing again from Linda Mar to Peralta, and finally decreasing at the outlet. This pattern can be better appreciated in Figure 27. In addition, there were significant differences when comparing the mean dissolved oxygen values calculated for the North Fork and the outlet to the other sites dissolved oxygen means.

The Board oxygen standard value for fresh water and the optimum range for aquatic organisms (minimum of 5 or 7 mg/L) (The San Francisco Bay Regional Water Quality Control Board 1995, Magaud *et al.* 1997) were achieved

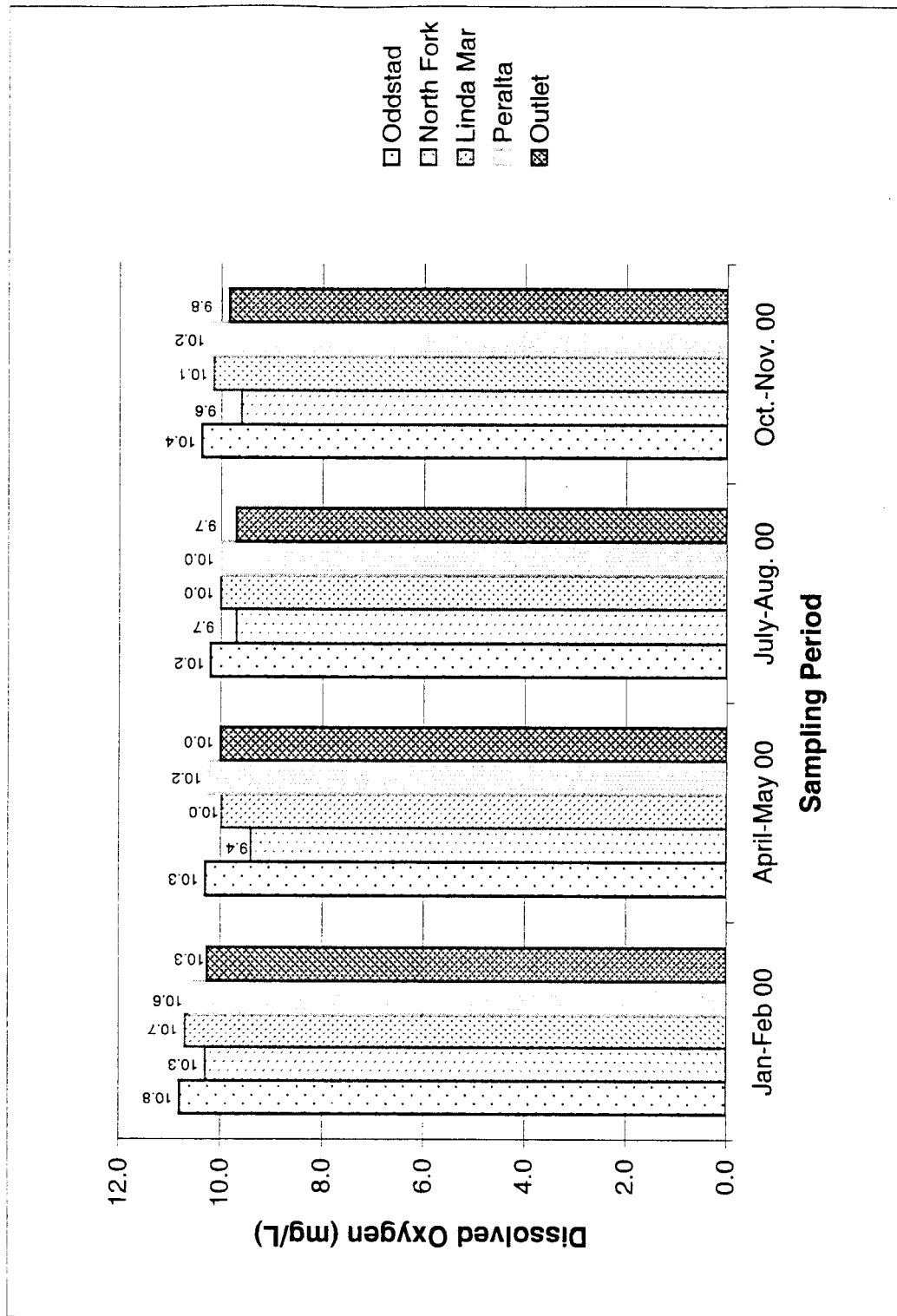


Figure 26. San Pedro Creek mean dissolved oxygen values for each of the sampling periods

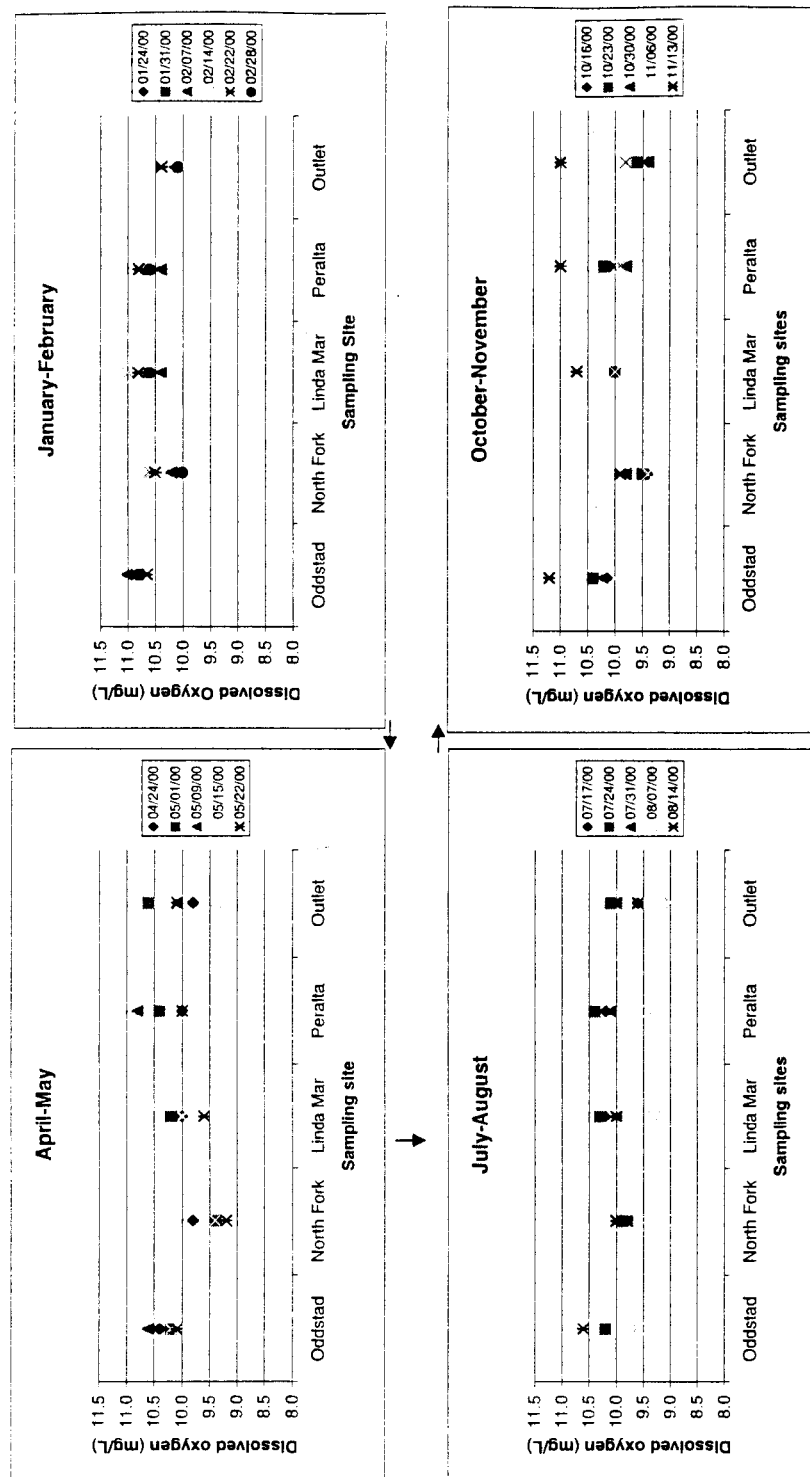


Figure 27. San Pedro Creek dissolved oxygen values recorded during the five consecutive Mondays of each sampling period

for all sampling periods and at all sampling sites, as shown in Table 9 and Table 10.

Nitrates, Nitrites, Nitrogen Ammonia and Phosphorus

Due to budget limitations, parameters such as nitrates, nitrites, nitrogen ammonia, phosphorus, metals, and volatile organic compounds were only analyzed for the April-May period. In addition, Oddstad and the North Fork sites were selected to evaluate these chemical parameters based upon the differences in land-use categories between the two sites.

Table 10 shows the nitrates, nitrites, nitrogen ammonia and phosphorus mean values recorded in the April-May period.

The North Fork reported the higher nitrate value (7.39 mg/L). Typical nitrate values in fresh water are less than 1mg/L (Hagebro *et al.* 1983). In addition, aquatic organisms can tolerate nitrate ranges between 0-100 mg /L (USEPA 1986). Comparing these standard values to the values recorded at the North Fork, the standard values for nitrates were not exceeded (Tables 9 and 10).

In relation to nitrite, no values were reported in any of the sites during the sampling period. In contrast, the total ammonia-nitrogen was only detected at the North Fork (0.243 mg/L). The regional Board, the EPA and literature do not

report any total ammonia-nitrogen standard. Therefore, comparisons between reporting limits and standards were not established.

The phosphorus mean value reported during late spring in Oddstad and the North Fork was 0.0233 mg/L (Table 9). The higher phosphorus value was reported at the North Fork (0.0292 mg/L) (Table 10). USEPA (1986) reports that in natural surface waters phosphorus ranges from 0.01-0.03 mg/L. Therefore, the North Fork did not exceed the reporting range. Appendix 7 shows each of the values reported during the five consecutive Mondays in late spring.

Metals and Volatile Organic Compounds

Several parameters of potential importance in surface waters were either not detected or only rarely detected. From the seventeen metals listed in Chapter IV, only silver and zinc were reported in late spring (Appendix 12). At the Oddstad site, silver was reported only once (0.01208 mg/L or 12.1 µg/L). On the other hand, zinc was reported in four out of five consecutive Mondays at the North Fork, with a mean value of 0.0102 mg/L or 10.2 µg/L (Table 9 and Table 10).

To derive fresh water aquatic life criteria for metals in San Pedro Creek, the Criteria Maximum Concentration (CMC) and the Criteria Continuous Concentration (CCC) for zinc and silver were used as described in Chapter IV (Table 11).

Table 11. Criteria Maximum Concentration (CMC) and Criteria Continuous Concentration (CCC) for zinc and silver

Metal	Criteria Maximum Concentration (CMC) (µg/L)	Criteria Continuous Concentration (CCC) (µg/L)
Zinc	331	331
Silver	0.34	ND

ND: No determined since EPA has not published an aquatic life criterion to calculate CCC for silver (USEPA 2000).

The Criteria for Maximum Concentration and Continuous Concentration reported for Zinc were the same whereas for the Silver the Criteria for Maximum Concentration was less than 1 µg/L. On the other hand, no volatile organic compounds were reported for both sampling sites.

BIOLOGICAL WATER QUALITY VARIABLES

As mentioned in Chapter IV, the EPA laboratory analyzed bacteriological parameters such as total coliform, *Escherichia coli*, using the Colilert method, and enterococcus using the Enteroalert method. Enterococcus were analyzed only in the parking lot and in front of the creek 's mouth sampling sites following the EPA protocol for salt-water bacteriological analyses. In addition, the San Mateo County Health Department (SMCHD) analyzed total and fecal coliforms in each of the seven sampling sites using the Multiple Tube Fermentation Method. Both laboratories overlapped in the analysis of the total coliform group. There

was approximately a ten-fold difference between the results reported by the two labs, with the EPA results higher than the results reported by the SMCHD.

Considering that the EPA laboratory has utilized since winter the federally-and currently state- approved method (Colilert), it was decided to used the total coliform results reported by this laboratory. When the SMCHD laboratory started to use the Colilert method, the results reported were similar to the EPA's results. Since the EPA laboratory did not analyze the fecal coliform group, the values reported by the SMCHD laboratory were considered. It is important to bear in mind that these results could also be off by approximately a factor of ten.

Five-week geometric mean values were calculated from the biological data to allow comparison with federal and state criteria. Also, geometric means instead of arithmetic means were used because of the high variability of bacterial data. If the data have low variability, the arithmetic and geometric means will be similar. However, one high result will cause a large change in the arithmetic mean but not in the geometric mean.

Total Coliform Bacteria

The highest coliform values were recorded during summer ranging from 1,800 to 31,000 MPN/100 ml. The lowest values were reported during fall ranging from 104 -9,614 MPN/100 mL (Figure 28). The total coliform mean

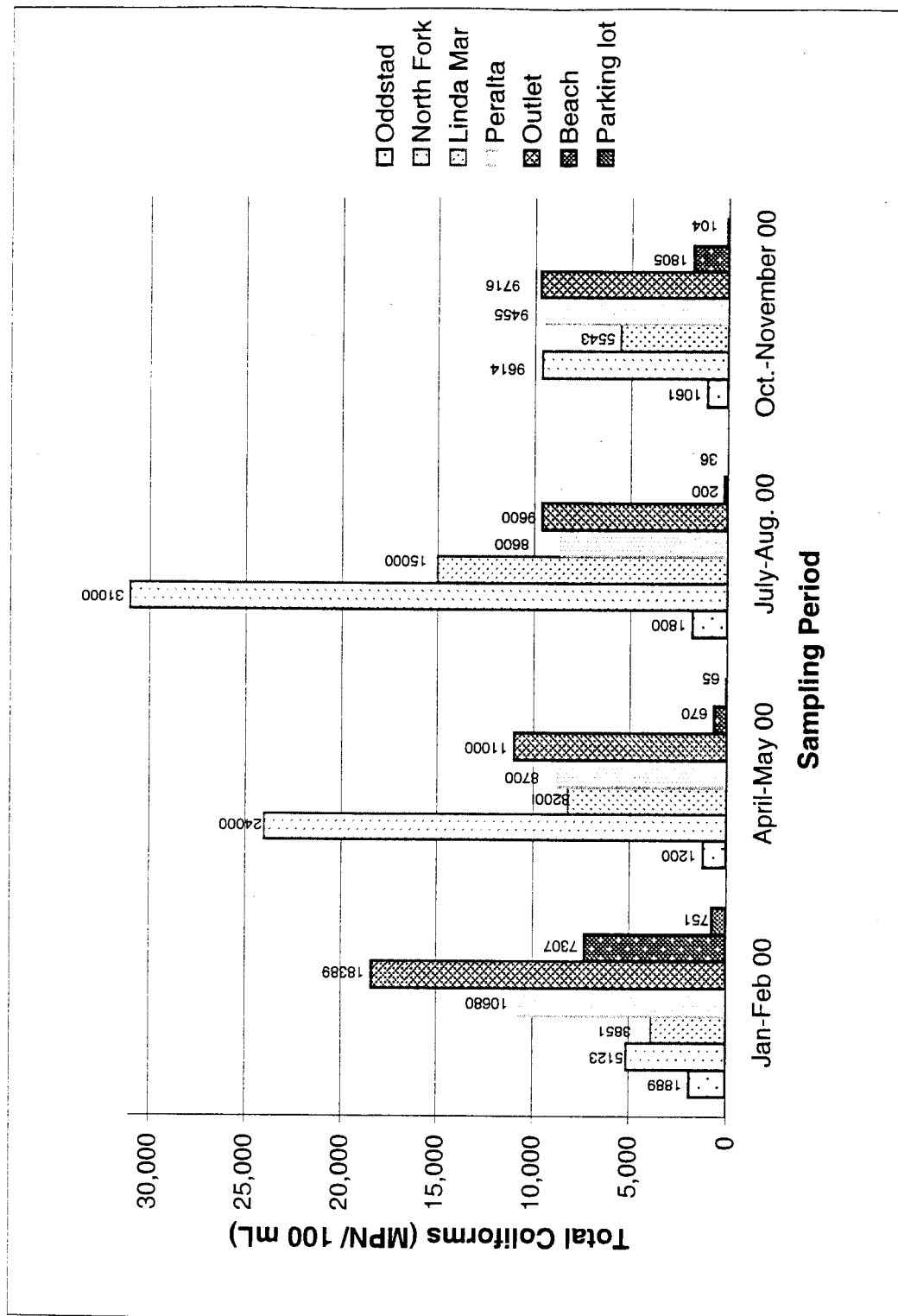


Figure 28. San Pedro Creek geometric mean total coliform counts for each of the sampling periods

values increased from winter (6,855.7 MPN/100 mL), to late spring (7,690.7 MPN/100 mL), and summer (9,462.3MPN/100 mL), and then, decreased in fall (5,328.2 MPN/100 mL) (Table 9).

The highest mean coliform values during the sampling year were recorded at the North Fork (17,434 MPN/100 mL), followed by the outlet (12,176 MPN/100 mL), Peralta (9,359 MPN/100 mL), Linda Mar (8,148 MPN/100 mL), and the beach (2,495 MPN/ 100 mL). The lowest values were reported at the parking lot (239 MPN/100 mL) and Oddstad sites (1,488 MPN/100 mL). There were significant differences when comparing the total coliform mean values of Oddstad and Peralta to the means calculated for the other sampling sites (Table 10).

As mentioned in the introduction of this study, San Pedro Creek is classified as a non-contact water recreation body. However, people do use the creek for various activities, such as playing, hanging out, studying nature, among others. Since there is no a standard total coliform value for fresh water classified as non-contact water recreation, the total coliform values reported in this research were compared to the EPA standard (10,000 MPN/100mL) for fresh water classified as water contact recreation due to the activities people practice in the creek (San Francisco Bay Regional Water Quality Control Board 1995). This point will further be discussed in detail. This standard was exceeded throughout the four sampling periods (Table 9). Only the Oddstad and parking lot sampling sites did not exceed the EPA standard throughout the year (Table

10). Appendix 14 shows the coliform values reported during the five consecutive weeks in each sampling period at the seven sampling sites.

Fecal Coliform Bacteria

The fecal coliform values tended to exceed 120/100 mL throughout the year except at Oddstad and the ocean surface sampling sites (Figure 29). Fecal coliform values increased from winter (444/100 mL) to late spring (823/100 mL), and then decreased in summer (582/100 mL) and fall (327/100 mL) (Table 9).

The highest mean fecal value was reported at Peralta (1,135/100 mL) followed by the outlet (885/ 100 mL), the North Fork (841/ 100 mL), and Linda Mar (613/100mL). Mean fecal values for Oddstad, the parking lot, and the beach sites were 74.5/ 100 ML, 97/100 mL, and 163/ 100 mL, respectively. There were significant differences when comparing the mean fecal values for Oddstad and the parking lot to the mean values of the other sampling sites (Table 10).

Comparing the mean fecal coliform values reported for each sampling period to the EPA standard of 2,000/100 mL for non-contact recreation waters (San Francisco Bay Regional Water Quality Control Board 1995), San Pedro Creek fecal coliform values did not exceed the EPA standard. At the sampling site level, Peralta, the outlet, and the North Fork exceeded the EPA standard during the sampling year. As mentioned in the total coliform results, it is important to consider the EPA standards for contact water recreation. This

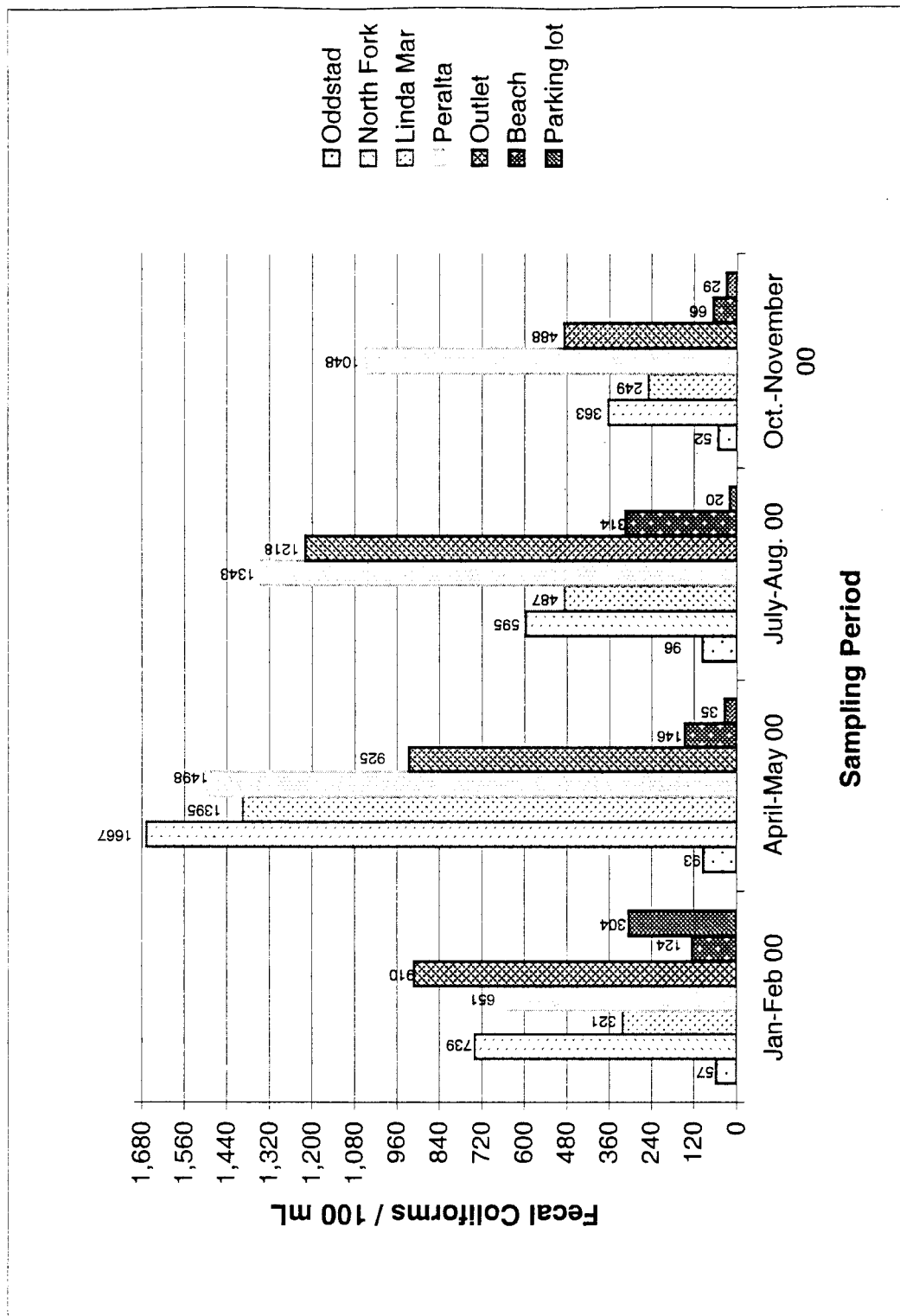


Figure 29. San Pedro Creek geometric mean fecal coliform counts for each of the sampling periods

standard for fecal coliforms is 200/100 mL (San Francisco Bay Regional Water Quality Control Board 1995). All the sampling periods and most of the sites, with the exception of Oddstad, exceeded the 200/100 mL fecal standard (Tables 9 and 10). The coliform values recorded during each sampling period at each sampling site are shown in Appendix 15.

Escherichia coli

The *Escherichia coli* values throughout the sampling year ranged between 11 and 2,400 MPN/100 mL (Figure 30). The *Escherichia coli* mean value during winter was 547 MPN/100 mL. In late spring and summer *Escherichia coli* values increased to 556 MPN/100 mL and 794 MPN/100 mL, respectively. In fall the bacteria count decreased to 340 MPN/100 mL (Table 9).

Escherichia coli values over 400 MPN/ 100 mL were reported during the sampling year at the outlet (1,552 MPN/ 100 mL), Peralta (1,316 MPN/ 100 mL), and North Fork (410 MPN/ 100 mL). Oddstad, Linda Mar, and the sampling sites located on the ocean surface (beach and the parking lot) reported *E. coli* mean values lower than 400 MPN/100 mL during the sampling year (Table 9 and Table 10).

As mentioned in Chapter III, there are no *Escherichia coli* standards required by the EPA for non-contact recreation waters. However, the *Escherichia coli* standard for contact water recreation of 235 MPN /100 mL (San

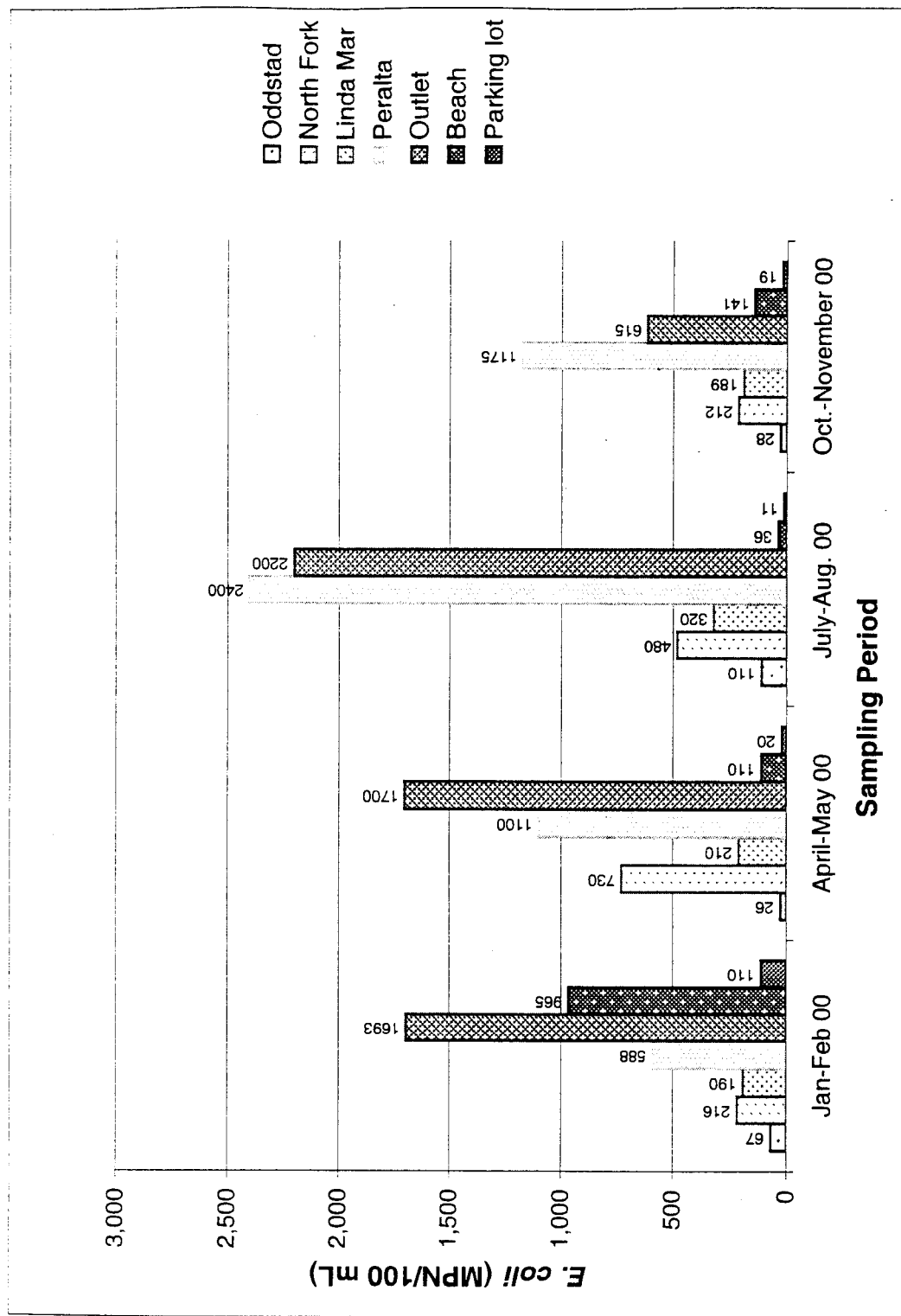


Figure 30. San Pedro Creek geometric mean *Escherichia coli* counts for each of the sampling periods

San Francisco Bay Regional Water Quality Control Board 1995) was considered. The results show that the *E. coli* standard was exceeded in all sampling periods (Table 9). In addition, only Oddstad and the parking lot did not exceed the EPA standard for *E. coli* (Table 10). Appendix 14 shows the *Escherichia coli* values reported throughout the study.

Enterococcus

As mentioned in Chapter IV, enterococcus at the parking lot and beach sites were analyzed following the EPA protocol for saltwater bacteriological analyses. Figure 31 and Appendix 14 show the bacteria values recorded during the sampling year. Enterococcus values ranged between 15 and 116 MPN/100 mL (Figure 31). Winter and fall samples yielded the highest enterococcus mean values of 40 and 66 MPN/100 mL, respectively (Table 9). The beach yielded higher mean values (50.8 MPN/100 mL) than the parking lot (28.3 MPN/100 mL) (Table 10).

Only the October-November period exceeded the EPA standard for marine waters (104 MPN/100 mL) (San Francisco Bay Regional Water Quality Control Board 1995). Moreover, none of the sampling sites exceeded the EPA standard throughout the year (Table 9 and 10).

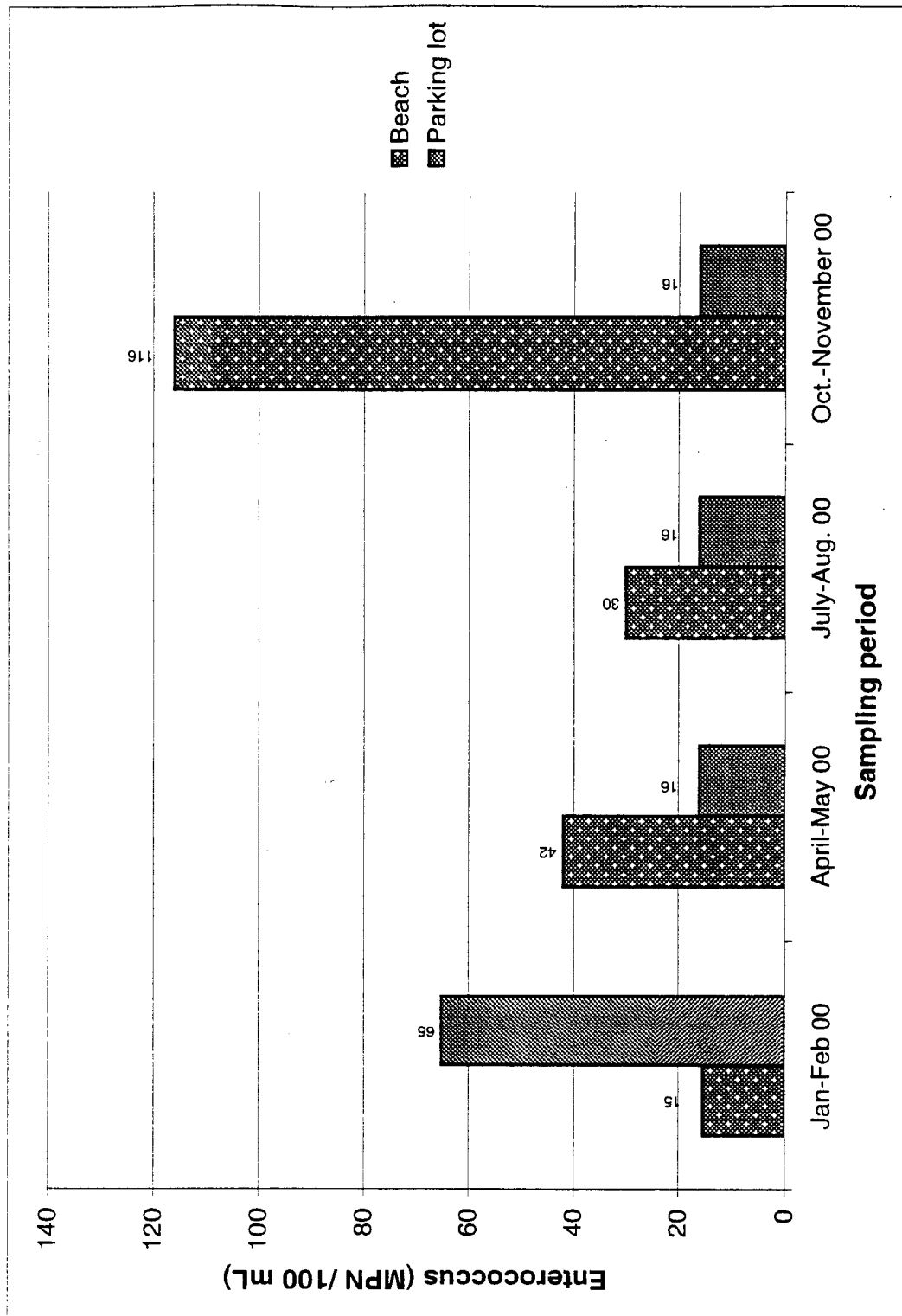


Figure 31. San Pedro Creek geometric mean enterococcus counts for each of the sampling periods

Pearson correlations and linear regressions

In order to understand the relationship between the water quality variables analyzed, the Pearson correlation coefficient and regression analyses were applied. Correlations between water temperature and pH, and water temperature and alkalinity were positive ($r = 0.377$ and $r = 0.364$, respectively) ($P > 0.01$). Water temperature and conductivity were correlated ($r = 0.517$) as well as water temperature and dissolved oxygen ($r = -0.631$) ($P > 0.01$) (Figure 32). In addition, the correlation between water temperature and dissolved oxygen was negative ($r = -0.631$) ($P > 0.01$). A positive and strong correlation was reported between discharge and turbidity ($r = 0.995$) ($P > 0.01$) (Figure 33). Furthermore, negative correlations were reported between discharge and pH ($r = -0.771$) ($P > 0.01$) and, discharge and electrical conductivity ($r = -5.43$) ($P > 0.01$) (Figure 33). A positive and strong correlation was reported between alkalinity and electrical conductivity ($r = 0.739$) ($P > 0.01$) (Figure 34). A positive and weak correlation was reported between conductivity and hardness ($r = 0.119$) ($P > 0.01$). A negative coefficient correlation lower than 0.35 was reported between dissolved oxygen - total coliforms, *Escherichia coli*, and pH.

Based upon the results found through this study, the following Chapter will analyze, explain and discuss the results reported in this Chapter in order to achieve the objectives of this research.

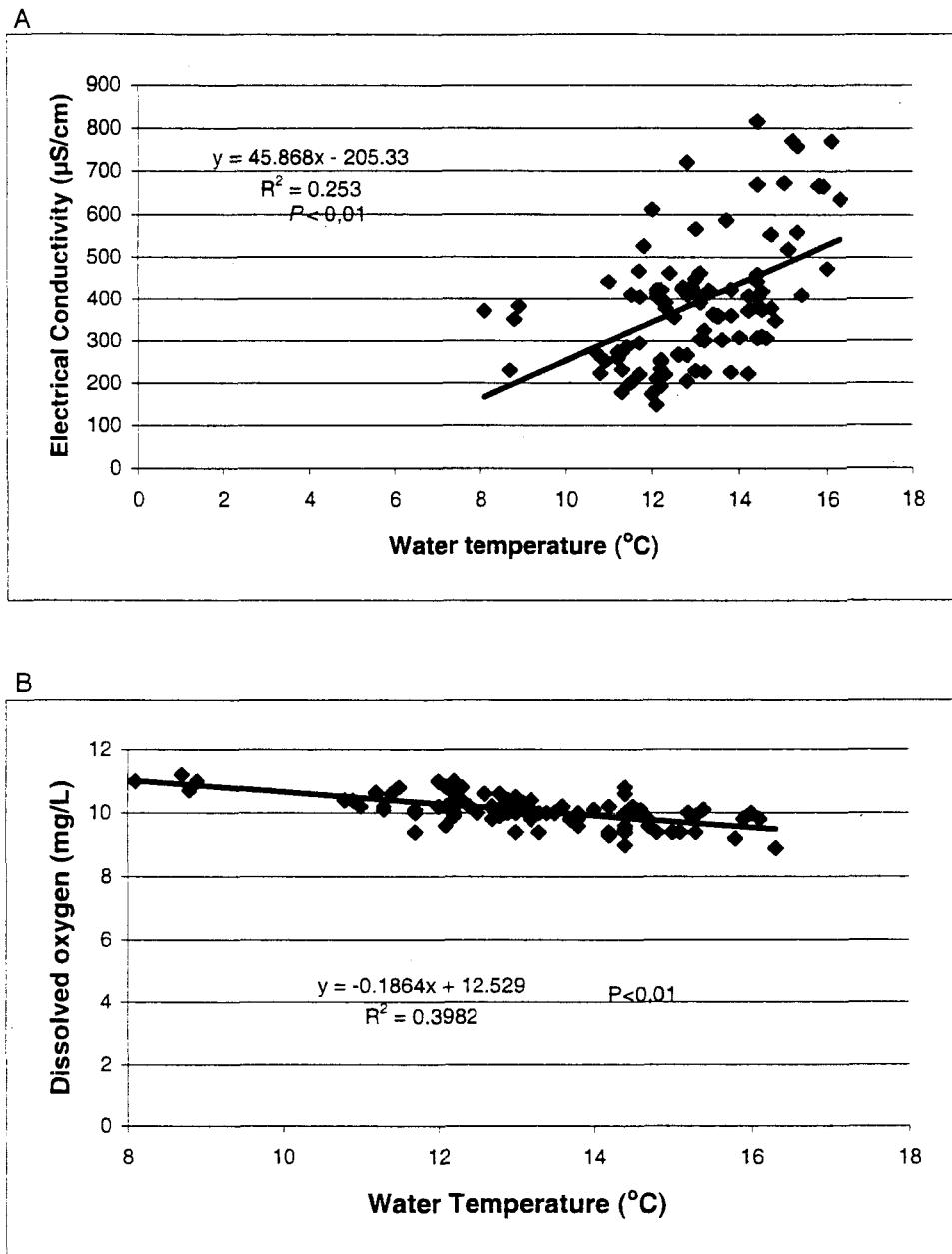


Figure 32. Correlation and regression between A) water temperature - E. conductivity. B) water temperature - dissolved oxygen in San Pedro Creek

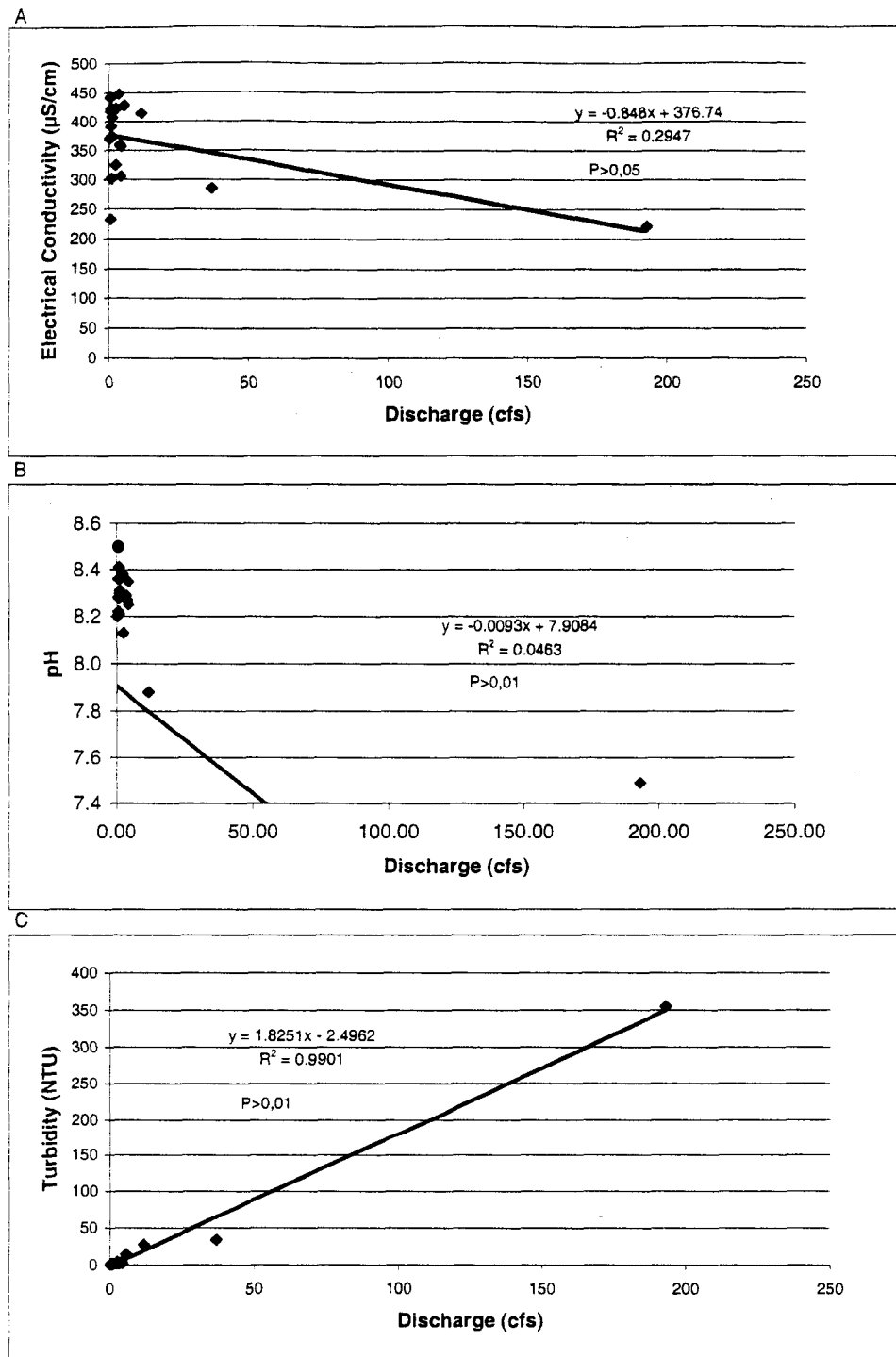


Figure 33. Correlation and linear regression between A) discharge and E. conductivity B) discharge and pH, and C) discharge and turbidity in San Pedro Creek

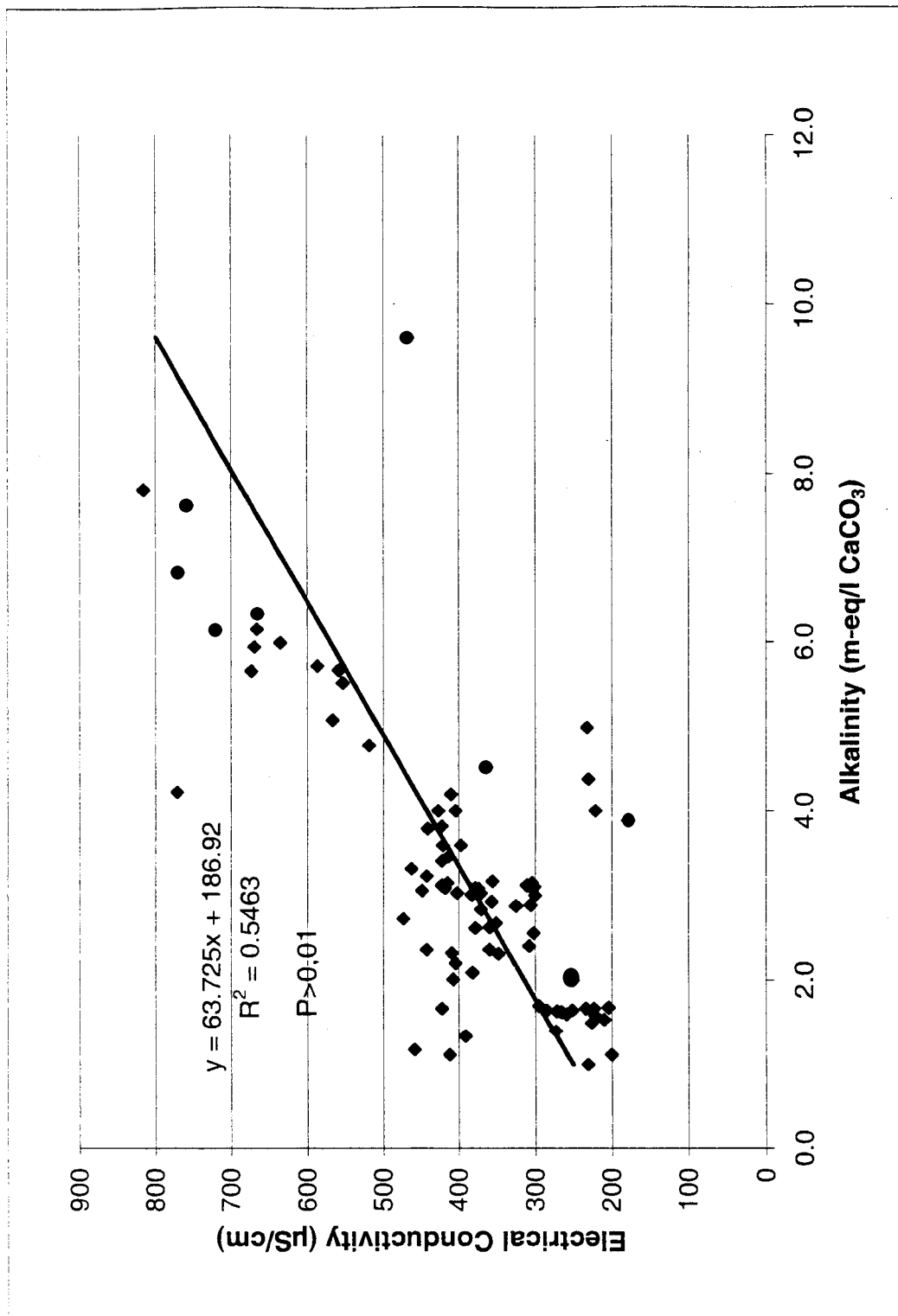


Figure 34. Correlation and linear regression between alkalinity and electrical conductivity in San Pedro Creek

CHAPTER VI

DISCUSSION

The discussion chapter will analyze the physical, chemical and biological findings reported in Chapter V. Also, patterns and relationships among the parameters evaluated in this study will be considered in order to address the research questions set for the study: What is the water quality of San Pedro Creek Watershed? and how does the water quality of San Pedro Creek change during different seasons and along the creek?

Climate

As mentioned in Chapter II, the climate in San Pedro Creek watershed is best described as a dry-summer maritime climate with cool, moist winters and mild, foggy summers (USDA 1991). Thus it comes as no surprise that in this study, most of the rainfall, high discharges and water level values, and low air temperatures were reported during the winter and fall seasons; and no rain, low discharge and water levels, or high air temperatures were recorded during the April-May and July-August periods (Table 7, Table 8, and Figure 19).

Overall, the climatic characteristics of the study area directly influenced the water quality of the creek reported throughout the year, as will be further discussed.

Water temperature

Water temperature values generally exhibited predictable seasonal variations, reflecting the marine climate and seasonal stream flow patterns. During winter and fall, storm-generated discharge increases coupled with colder air temperatures produced lower water temperature values during those sampling periods (Figure 19). In contrast, the lack of rain, low discharge values, and increase in air temperature may explain the higher water temperature values during late spring (April-May) and summer (July-August).

The North Fork temperatures were higher than expected. One might expect to have lower water temperatures at the North Fork sampling site since the water at this point comes from a culvert where no sunlight penetrates. It is possible that in summer, storm drains sources may be warmer and in winter, temperatures at depth will be warmer than the surface.

Another intriguing idea may be the decomposition of sanitary sewage. During most of the sampling periods, the researcher listened to a dripping noise inside of the culvert. The San Pedro Creek watershed area has a separated system of pipes to handle sanitary sewage and stormwater systems, though leakage of the sanitary sewage system is a possibility. As observed by Hvitved (1982), inputs coming from sanitary sewage and storm systems may increase water temperature since the degradation of organic matter increases this physical parameter. Others have noted that changes in water temperature

influences and is influenced by many chemical and biological processes (Tchobanoglous and Schroeder 1985, and Chapman 1997). At the North Fork warmer temperatures are associated with high bacterial counts (Figures 28, 29 and 30); high values of chemical parameters such as pH (Figure 20), alkalinity (Figure 22), hardness (Figure 23), and total dissolved solids measured as electrical conductivity (Figure 24); and the lowest values of dissolved oxygen (Figure 26). A connection is thus likely between these elevated temperatures and pollution from leaking sewer lines and other urban runoff sources that feed the North Fork.

Water temperature values registered at sites close to the mouth of the creek were approximately 1 C° degree (1.8 F°) higher than at other sites (Figure 17). This result may be explained due to the absence of riparian vegetation at these sampling sites. The dense riparian vegetation and the low organic load reported at the Oddstad site may explain the low water temperatures registered at that site (Figures 17). This result may be explained due to the absence of riparian vegetation at these sites. The dense riparian vegetation and the low organic load reported at the Oddstad site may explain the lower temperatures registered at that site (Figures 26, 27 and 28).

Overall, the water temperature along the creek was fairly stable during the sampling year, remaining within the optimum range for aquatic organisms (between 14 and 16 °C (57.8 and 60.8°F) (Magaud *et al.* 1997, Rowland 1998).

This is good news, because for freshwater fish water temperature is extremely important since their metabolic rate and many of their physiological functions are fundamentally influenced by temperature (Morgan *et al.* 1998).

Turbidity, Coliform and Fecal Bacteria, *Escherichia coli* and Enterococcus

The seasonal changes in the area of study clearly influenced other physical parameters such as turbidity. The highest turbidity values reported during the winter period (Figure 18) were produced by the rainfall events that increased discharge, and thus runoff, organic matter and the creek sediments suddenly put in suspension by the accelerated water flow. The positive and strong correlation between turbidity and discharge (Figure 33) is due to the greater transport capacity of the high flows, and the available supply of sediment within the watershed. High turbidity values during wintertime and the correlation between turbidity and discharge have also been reported by Hvitved (1982) and Dick *et al.* (1983) in their study developed in Ohio.

The sources of turbidity at Oddstad, Linda Mar, Peralta and the outlet, where the creek is not culverted, are runoff and sediments in suspension due to the interaction between the water, the soil biota, and the streambed. The North Fork, the only culverted sampling site, receives turbidity in discharges from storm systems and likely also from the sanitary sewage.

High turbidity values reported during winter could have affected the aquatic ecosystem in several ways such as clogging fish gills, affecting egg and larvae development through abrasion, loss of visual efficiency in feeding, and interference in food gathering by filter-feeding insects on invertebrates (Goldman and Horne 1983, Waters 1996, Matuk *et al.* 1997, May *et al.* 1997). High turbidity values could have also decreased light penetration reducing photosynthesis, and increased invertebrate drift which would reduce benthic populations (Goldman and Horne 1983, Waters 1996, Matuk *et al.* 1997, May *et al.* 1997). However, it is important to mention that turbidity was most critical during winter, and that the turbidity values during the sampling year were within the tolerable ranges for the aquatic ecosystem.

Hvitved (1982), and Magaud *et al.* (1997) report that rainfall increases organic matter in a stream, arising not only from the runoff itself but also from the sediment put in suspension by the flow. Increasing organic sediment transportation can increase bacterial pollution problems since small particles are vectors of enteric bacteria. The results obtained in this study showed, in most of the bacteriological analyses, a different pattern. The coliform and fecal bacteria, and *Escherichia coli* were higher during the dry season (Figures 28, 29, and 30). This situation might be explained by the fact that during April-May and July-August, the discharge was low (Figure 19), yet the organic input, possibly coming from the sanitary sewage and storm systems, persisted. Therefore, a higher

concentration of bacteria with less dilution, due to lack of rain, might be significant factors explaining the high counts of bacteria during dry seasons. This pattern was also reported by Olayemi (1994), van Asperen *et al.* (1998), and Baudart *et al.* (2000), who recorded high bacteria loads in summer in Nigeria, the Netherlands, and in a coastal river on the western Mediterranean coast, respectively.

As mentioned in chapters I and V, the Regional Water Quality Control Board has classified San Pedro Creek as a *non-contact water recreation* body based on its beneficial uses (Regional Water Quality Control Board 1995). However, San Pedro Creek should be classified as a *water contact recreation body* since people, particularly children, have body contact with the creek and ingestion of water could be possible. Moreover, the creek flows into the ocean at Pacifica State Beach, a highly popular place especially for surfing. Comparing the bacteriological results of this study to the standards for *contact water recreation* established by the EPA (total coliform bacteria: less than 10,000 MPN/100 mL, fecal coliform: less than 200 MPN/100 mL, and *Escherichia coli*: 235 MPN/100mL) (San Francisco Regional Water Quality Control Board 1995), results exceeded the Regional Board standards throughout the sampling year. Only Oddstad and the parking lot met EPA standards for total coliforms and *E. coli*, and only Oddstad did not exceed the EPA standard for fecal coliforms. Oddstad did not report high microbiological contamination likely due to its

location in the San Pedro Valley County Park. The land-use categories in the park (herbaceous rangeland, evergreen forest and shrub and brush rangeland) protect the site from the effects of urbanization that affect the other sampling sites. Microbiological counts reported at Oddstad would come from waste products from pets, birds, and wild animals. Bacterial pollution of ocean water diminishes with distance from the creek mouth: while the “beach” sampling site at the mouth is somewhat polluted, dilution had eliminated the effect as measured at the parking lot site 350 meters up the coast.

The presence of fecal and coliform bacteria, and *E. coli* in the creek may pose a potential risk to public health since people could get fecal-born diseases such as hepatitis, cholera, gastroenteritis, among others (Oleyami 1994, van Asperen *et al.* 1998).

Despite the fact that there is limited literature about the possible effects of total coliform, fecal coliform bacteria, *Escherichia coli* and enterococcus on aquatic systems, high counts of these groups of bacteria may cause problems in the ecosystem. Xu *et al.* (1993) reported an acute disease in rainbow trout caused by *E. coli*. The disease was characterized by darkening of body color, reddening of anus and some fins, and anemia in gill filaments (Xu *et al.* 1993). Margaleff (1996) observed that bacteria may change organic matter and its composition, the conversion of inorganic compounds, the dissolved oxygen

levels in the aquatic ecosystem, among others. As a consequence, these microorganisms could affect several trophic levels in the aquatic system.

On Chapter V, I reported a negative correlation between dissolved oxygen and total coliforms, and between dissolved oxygen and *E. coli* suggesting a bacterial cause for reductions in dissolved oxygen as has been observed elsewhere (Margaleff 1996).

Dissolved oxygen

In this study, dissolved oxygen was highly influenced by seasonality (Figure 26). As mentioned in Chapter III, the solubility of oxygen in water decreases with increasing temperature. Thus, freshwater can hold more oxygen in winter than in summer (Rowland 1992, Wetzel and Likens 2000), which fits with the negative correlation between water temperature and dissolved oxygen observed in this study (Figure 32). Though turbidity was also high during winter (Figure 18), and this parameter increases water temperature and thus, in turn, may reduce dissolved oxygen values (Hvitved 1982 and Magaud *et al.* 1997), turbidity did not appear to have much effect on the dissolved oxygen availability in San Pedro Creek. The low water temperature (Figure 17) and flow rate (Figure 19), and the continuous replenishment of water during the January-February and October-November periods helped the aquatic system to maintain the dissolved oxygen levels required by the Regional Board and aquatic

organisms such as steelhead trout, a range of minimum concentrations of 5 to 7 mg/L (San Francisco Bay Regional Water Quality Control Board 1995, Magaud *et al.* 1997). During dry seasons (April-May and July-August), the low flow rate, increase in water temperature and the high bacteria count decreased the dissolved oxygen availability in the creek.

As mentioned earlier, bacteria decrease dissolved oxygen levels through biological respiration (Rheinheimer 1994, Matuk *et al.* 1997). However, the dissolved oxygen values during the sampling year met the Regional Board standards and optimum values for aquatic organisms. Factorss such as continuous water movement, low water levels (Figure 19), and the presence of riffles along the creek help the water body achieve the appropriate dissolved oxygen levels throughout the sampling year.

The difference in dissolved oxygen levels among the sampling sites might be explained by the fact that the creek water at the North Fork comes from a culvert where the diffusion at the air-water interface is more difficult, restricting the oxygen availability at that sampling point. Moreover, the organic and bacteria inflow getting to the North Fork, Linda Mar, Peralta and the outlet sampling sites (Figures 28, 29, 30) may affect the dissolved oxygen levels.

pH and alkalinity

The pH was also affected by seasonal changes. Throughout the sampling year, creek pH values were above 7.0. Therefore, it is possible to consider the creek's water as slightly alkaline or basic. The pH is controlled by the dissolved chemical compounds and biochemical processes in aquatic systems (Faus and Aly 1981, Clesceri *et al.* 1989). During April-May and July-August, algal productivity may have increased due to the decrease in water flow and increase in water temperature (Figures 17 and 19). Phytoplankton and microphytes reduce the amount of carbon dioxide, as a result of photosynthesis, diminishing the production of carbonic acid, thereby increasing the pH (Wagner *et al.* 1997). This situation may explain the negative correlation between pH and discharge during the study year (Figure 33). One might think that if phytoplankton content increases, dissolved oxygen values would also increase since high amounts of algae produce more dissolved oxygen in the aquatic ecosystem (Margaleff 1996). However, the dissolved oxygen dynamic (Figure 25) in San Pedro Creek is different and this is reflected in the negative correlation between dissolved oxygen and pH, and dissolved oxygen and water temperature. These results suggest that the creek is not highly productive. Therefore, algae formation is not significant, and as a consequence, dissolved oxygen values were not higher during late spring and summer.

The negative correlation between discharge and pH is due to the fact that pH is controlled by the dissolved chemical compounds (Faus and Aly 1981, Clesceri *et al.* 1989). These compounds might be less concentrated in the water when the discharge is higher, due to shorter residence and the greater dilution, explaining the relationship between the two variables (Figure 33).

Alkalinity should be considered when analyzing pH because it determines the stream's ability to neutralize acids (USEPA 1991). Thus, any acid added to the water body could cause an immediate change in the pH. The alkalinity values reported throughout the year (63- 367 mg/L CaCO₃) suggest that San Pedro Creek is highly buffered against changes in pH. Moreover, these alkalinity values are higher than the alkalinity average values reported for Whitehouse Creek in San Mateo County (60-68 mg/L CaCO₃) (San Gregorio Environmental Resource Center 2000). This difference may be explained by the presence of limestone in San Pedro Creek (La Calera series), which contains compounds such as calcium carbonate (CaCO₃) that will affect the alkalinity values. Whitehouse Creek does not have this parent material (U. S. Department of Agriculture 1954).

Alkalinity values reported in San Pedro Creek during the year of study were not less than 20 mg/L but higher than 250 mg/L. Therefore, it is likely that the creek is unproductive since, usually, waters with alkalinities in that range contain too little carbon dioxide for primary production (Rowland 1998).

The decrease in water discharge and the continuous human activity inputs getting into the creek may explain the alkalinity increase reported from winter to fall. High alkalinity values reported at the North Fork, the low values recorded at Oddstad and similar alkalinity values at Linda Mar, Peralta and the outlet, might be related to the level of urbanization in the creek and leaching of calcium carbonate (CaCO_3) from the concrete culvert.

Another possible explanation for the spatial variability in alkalinity could be the influence of geology on the water quality of the creek. The greenstone and sandstone type of soils at the North Fork (Figure 3) have carbonate and bicarbonate compounds, such as calcium carbonate (CaCO_3), that can be leached into the creek influencing the concentration of these compounds in the water, and thus, in turn, affecting the alkalinity values. Sandstones include rocks that were formed in shallow marine basins in the vicinity of continents, as well as sediments deposited in deep ocean basins far from land (Faure 1998). Thus, sandstone is a mixture of detrital grains and chemically precipitated carbonate cement (Faure 1998). The mixture of sandstone, and minor exposure of limestone, greenstone, granitics and alluvium types of soils at Linda Mar, Peralta, and the outlet may also influence the alkalinity values reported at those sites.

Electrical Conductivity and Hardness

As in most of the parameters previously mentioned, water temperature also affects electrical conductivity (Figure 23), a surrogate for total dissolved solids. Temperature increases the ion mobility. Therefore, the warmer the water, the higher the conductivity (Chapman 1997). This fact combined with dilution may explain partly the conductivity seasonal variation reported in San Pedro Creek.

High electrical conductivity values at the North Fork, low values at Oddstad, and similar values reported at Linda Mar, Peralta and the outlet throughout the year might be the consequence of human activities inputs in water body. Hvitved (1982) reported that discharges from urban runoff and sanitary systems could raise the conductivity because of the presence of inorganic dissolved solids such as chloride, nitrate, sulfate, and phosphates anions (ions that carry a negative charge).

Another possible explanation for the high values reported at the North Fork may be the influence of geology in the water. The greenstone and sandstones produce soils rich in phosphorus, magnesium, sodium, calcium, iron, among others ions, which affect the conductivity (Faure 1998).

Electrical conductivity is also related to hardness since hardness is the measure of the total concentration of metal ions, primarily calcium and magnesium (USEPA 1991). Considering that conductivity values at the North

Fork were close to 1,000 $\mu\text{S}/\text{cm}$ (over this value, the freshwater body is considered polluted), inputs at this sampling site and CaCO_3 from the concrete culvert should be considered. If 1,000 $\mu\text{S}/\text{cm}$ value is reached, parameters such as alkalinity, hardness, and pH could be modified exceeding the Regional Board Standards, affecting the requirements for aquatic organisms.

In the periods where hardness was evaluated (July-August and October-November), the values were above 200 mg/L of CaCO_3 . Therefore, it is possible to consider the creek's water as "hard".

Differences in hardness values along San Pedro Creek are due to the urbanization effects on the watershed and the influence of the geology on the water. Hardness values in San Pedro Creek exceeding the hardness criteria for coldwater species - between 10-400 mg/L CaCO_3 - (Mays 1996 and Rowland 1998) could inhibit the water uptake by the fish eggs. This process is extremely important in the formation of the perivitelline fluid (fluid between the egg cell membrane and the viteline membrane) (Heath 1987). Moreover, high hardness values may affect metabolic and muscular activities, as well as the stability of the cellular membrane in the aquatic organisms (Heath 1987).

Comparing the hardness values reported in San Pedro Creek (> 200 mg/L of CaCO_3) to values reported at the Whitehouse Creek (125 mg/L of CaCO_3), (San Gregorio Environmental Resource Center 2000) one can see how these

creeks differ, and again may be due to differences in land use, bedrock/soil type, culverting, or other sources.

Metals and Volatile Organic Compounds

The zinc values reported during the April-May sampling period at the North Fork did not exceed the Criteria for Maximum Concentration (CMC) and the Criteria for Continuous Concentration (CCC) (Table 11), indicating that aquatic organisms can survive in the creek without deleterious effects. Sources of zinc at the North Fork might be urban runoff from the breakdown of metal products, and vehicle wear, among others, and possibly the leachate from the landfill located in the upper part of the North Fork (El-Fadel *et al.* 1985, Richter 2000). Toxic pollutants commonly found in urban runoff such as lead, copper, volatile organic compounds, and even higher concentrations of zinc, were expected at the North Fork. The low metal results and the absence of volatile organic compounds reported in this study were a surprise since the North Fork is highly urbanized. The absence of these pollutants, and the low concentration of zinc at the North Fork could be explained by the fact that the water samples were taken in days without heavy rain, thus minimizing urban runoff sources.

In relation to silver, the Criteria for Maximum Concentration (CMC) (0.74 µg/L) was exceeded by the value reported at Oddstad (12.1 µg/L). Silver is a potential toxicant to fish that may cause a decrease in their reproduction.

Disinfectants are one source of silver in urban runoff. The Oddstad site is located in the San Pedro Valley County Park, an area without residential development, but silver may come from disinfectants used in the Park facilities.

Water hardness gives protection against the toxicity of metals for aquatic organisms (USEPA 2000). Thus, high hardness values reported along the watershed reduced the lethality of the metals protecting the creek from deleterious effects (USEPA 2000).

Total Suspended Solids

High total suspended solids values, reported during the April-May sampling period at the Oddstad site, were not expected since Oddstad is located in San Pedro Valley County Park. Richter (2000) reports that sediments are one of the major categories of urban pollutants and their concentration in urban runoff are particularly problematic because of their ubiquitous nature, and the fact that many other pollutants occur in association with sediment particles. We expected to find high suspended solid values at the North Fork considering the incidence of urbanization there, but not at the Oddstad sampling site. It is possible that decaying vegetation, plankton, algae, regular inorganic sediments, fine organic debris, park workers hosing off parking lots or vehicles yards, or sediments coming from trails could have been the source of the suspended solids reported

at the Oddstad site. Lack of rainfall input and corresponding runoff during April-May may explain the absence of suspended solids at the North Fork.

The total suspended solid values reported in this study contradict the results reported by May *et al.* (1997) who found the highest concentrations of total suspended solids in the most developed basins in the Puget lowland stream (Washington State). This difference might be related to a contrast in the stage of development between the Puget lowland stream and San Pedro Creek since early development produces more sediment than later development, where pavement may decrease sediment yield (Wolman 1967). May *et al.* (1997) reported highest concentrations of total suspended solids in the most developed basins. The limited total suspended solid data collected in this study did not allow us to analyze how solids are related to urbanization, and how seasonality may affect this physical parameter.

Nitrate, Nitrite, Nitrogen Ammonia and Phosphorus

Due to budget limitations, analyses of these elements were not possible. It would have been ideal to have assessed the seasonal and spatial patterns in the concentrations of nitrates, nitrites, nitrogen ammonia, and phosphorus in the creek. It is important to point out that nitrate values reported in this study are only for one season and may not represent the true pattern of this nutrient in the watershed.

Nitrate is usually the most important form of combined nitrogen found in natural waters (Effler *et al.* 1990). The higher nitrate value reported at the North Fork site could come not only from natural sources such as plant and animal debris, land drainage, as well as from significant sources such as inorganic fertilizers, and waste waters, including leachates from the landfill located in the upper part of the North Fork. Nitrate values at Oddstad could come from land drainage, plant debris, and waste products from pets, birds, and wild animals commonly found in urban areas. The difference in land use between Oddstad and the North Fork sites may also explain the difference in nitrate presence between both sampling sites. Nitrate concentrations at Oddstad and the North Fork differed by more than 5 mg/L NO_3 , which often indicates human and animal waste pollution, or fertilizer runoff (Hagebro *et al.* 1983).

The nitrite ion is rapidly oxidized to nitrate (Effler *et al.* 1990); this situation may explain why nitrite values were not reported during the April-May sampling period. However, we expected to find high concentrations of nitrite at the North Fork site since this chemical parameter is associated with high microbiological counts (Chapman 1997).

The ammonia values reported at the North Fork could come from the sewage system, which (as it was mentioned before) could be leaking into the creek. In addition, fertilizers used by watershed residents could be a source of

ammonia. The difference in land use between Oddstad and the North Fork may also affect the ammonia values reported during the sampling period.

Human activities could influence the different phosphorus values reported at Oddstad and the North Fork. Sources of phosphorus at the North Fork may include runoff from fertilized lawns, animal wastes and domestic runoff, particularly detergent discharged into the sanitary and storm sewer systems. In addition, natural sources of phosphorus include soil and rocks since in greenstones and sandstones phosphorus is particularly common (Faure 1998). Sources of phosphorus at Oddstad may include animal wastes and natural sources such as soil and rocks.

Overall, the results and analyses in this study indicate that there were seasonal and spatial variations in the physical, chemical and biological parameters evaluated in San Pedro Creek during the year 2000. Most of the bacterial parameters analyzed along the watershed did exceed the Regional Water Quality Control Board's reporting limits for *contact water recreation*. Alkalinity values reported for the sampling periods and for the North Fork site exceeded the standards reported in the literature. The limited amount of data for total suspended solids, nitrogen, metals and phosphorus limited the assessment of the seasonal and spatial variations of these parameters. Chapter VII will discuss the conclusions of this study and some future research directions.

CHAPTER VII

CONCLUSIONS AND RECOMMENDATIONS

Water quality studies provide valuable information for water managers seeking to maintain levels of freshwater quality and ecological integrity.

This study examined the water quality of San Pedro Creek in different seasons throughout the year 2000, comparing different sites along the stream, and compared in-stream physical, chemical and biological characteristics of the watershed to the Regional Water Quality Control Board, EPA and literature standards.

The results, analyses and discussions of this study indicate that there are seasonal and spatial variations in the physical, chemical and biological parameters evaluated in San Pedro Creek during the year 2000.

The dry-summer maritime type of climate of San Pedro Creek watershed directly influenced the water quality of the creek. Highest values of alkalinity, hardness, electrical conductivity, pH, total, fecal coliform bacteria, *Escherichia coli* and enterococcus were reported during the April-May and July-August sampling periods. The lowest values of water temperature, and highest values of turbidity and dissolved oxygen were reported during the winter period (January-February and October-November). Rainfall events and changes in the water temperature clearly influenced these patterns.

Spatial variations were evident when comparing the sampling sites along the creek. Generally, the highest water temperature, pH, alkalinity, hardness, electrical conductivity and bacteriological values were reported at the North Fork. In addition, lower values of turbidity and dissolved oxygen were reported at that sampling site. Similar physical, chemical and biological values were reported at Linda Mar, Peralta and the Outlet sampling sites. The lowest values for parameters such as pH, alkalinity, conductivity, hardness, electrical conductivity, bacteriological analyses and water temperature were reported at Oddstad (the “control” sampling site). In addition, the highest dissolved oxygen and turbidity values were reported at the “control” site. Land-use categories, urbanization, inputs from the sewage and storm systems, and the influence of geology may explain the spatial variations and the water quality characteristics reported in this study.

San Pedro Creek is a well-oxygenated creek with somewhat alkaline water, at a fairly stable water temperature, with relatively “hard” waters and moderately conductive. Its water quality met most of the San Francisco Regional Water Quality Control Board, EPA and literature standards for a freshwater habitat. This study demonstrated that there is a disconnect between the creek uses and the Beneficial Uses assigned by the Regional Water Quality Control Board. The Regional Water Quality Control Board stream’s classification depending on beneficial uses, considers San Pedro Creek as a non-contact

water recreation body. However, the creek is utilized for water contact recreation.

Considering the real beneficial uses the creek provides to San Mateo County and the community of Pacifica, San Pedro Creek bacteriological contamination is a critical concern. The creek samples did not meet the EPA's bacteriological standards for water contact recreation bodies. Water quality is impaired, possibly due to inputs from the sewage and storm systems, and the creek's bacteriological contamination may pose a risk to public health even though it provides a significant habitat for aquatic species such as the steelhead trout. The disconnect between classification and reality, its policy and enforcement implications, merit further attention.

These findings suggest that an immediate management intervention is needed to protect the watershed, the aquatic community and the people who use the creek. The Regional Water Quality Control Board, San Mateo County and the City of Pacifica need to communicate to the residents of the area the unsafe water quality characteristics of the creek for contact recreation. Also, San Pedro Creek's beneficial use designation must be changed to a water contact recreation body for the reasons provided in Chapter VI.

The disparity between San Pedro Creek's beneficial use designation and the reality of the creek's use by residents suggests a problem that may prevail at other coastal California streams, and even nationwide. A strict and detailed

review of streams' beneficial use designations should be carried out by the Regional Water Quality Control Board with the coordination and help of the counties, cities and groups interested in helping to protect, enhance and maintain the fresh water bodies of California and United States and in protecting those who enjoy these water bodies.

Despite limitations, the routine water quality monitoring method used in this research was an intense, cost-effective (in the long term) and robust approach that provided important information about the water quality characteristics of San Pedro Creek, as well as a first approach to pinpoint the main causes of pollution affecting the watershed.

This study raises some ideas for future research. The highest priority for decision-making processes is to pinpoint the exact cause(s) of the excessive bacteriological loading of the creek. Methods such as fecal coliform-to-fecal streptococci ratios, streptococcal population profiles, species-specific indicators, bacteriophages/coliphages and viruses, multiple antibiotic resistance, testing for optical brighteners and caffeine, coprostanol, fluorescent dye tracing and DNA Ribotyping/genetic fingerprinting would help to track down bacteria and to identify human versus non-human sources of fecal contamination in the creek (USEPA 2000a).

The San Pedro Creek water quality monitoring program must be continued. A more spatially intensive water quality monitoring along the North

Fork would help to isolate sources of pollution affecting the creek. Also, samples must be collected over a period of several years to account for annual variability. The continuity of the water quality program will determine the effectiveness of management practices and activities implemented in order to improve the water quality of the creek. A complete monitoring analysis of parameters such as total suspended solids, nitrate, nitrite, nitrogen ammonia, phosphorus and volatile organic compounds is necessary to understand their dynamics and the possible effects of the landfill, located in the upper part of the North Fork, upon the creek. In addition, water quality research in parameters such as chlorophyll *a*, nitrogen and phosphorus would provide information about the seasonal variability of these nutrients, the primary productivity of the creek and whether the creek could be affected by eutrophication.

A next step would be the study of the in-stream biological integrity of the watershed. An inventory list of plankton and benthic communities, as well as an in-stream salmonid habitat characterization, including parameters such as large woody debris (LWD), and intragravel dissolved oxygen measurements, are required. Knowledge of the biological communities in the creek will provide significant information about in-stream characteristics, since in-stream physical-chemical changes clearly influence biological communities that inhabit the watershed. In addition, analyses of sediments would be significant to protect the creek's biological communities since streambed quality, including fine sediment

content and streambed stability, affects benthic macroinvertebrates and fish spawning.

Finally, water protection, educational programs, political change involving dialogue and cooperation between city, county, local agencies, institutions and state would provide a powerful means to mitigate and solve the pollution problem affecting San Pedro Creek.

Increasing the interest in water resource pollution in California, the nation and worldwide will help to reduce costs not only in terms of human disease, waste water treatment and drinking water purification, but in terms of the degradation of aquatic ecosystems and the loss of irreplaceable habitats.

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Appendix 1.

FIELD COLLECTION DATA SHEET

San Pedro Creek

Site: _____
Time: _____

Date: _____

Field Parameters

Air Temperature (°C)

Weather Conditions

Day before _____

Sampling day _____

General Field Conditions-Comments

Dissolved Oxygen

Temperature (°C)	
Dissolved oxygen (mg/l)	

pH: _____

Conductivity: _____

Appendix 2

FLOW RATE FOR THE PERALTA BRIDGE SAMPLING SITE SITE

Date: _____

WIDTH (feet)	DEPTH (feet)	VELOCITY (feet/sec)

Appendix 3
Turbidity, alkalinity and Hardness collection data sheet

TURBIDITY READING

SITE	READING 1 (NTU)	READING 2 (NTU)
1 Oddstad		
2 North Fork		
3 Linda Mar		
4 Peralta		
5 Outlet		
6 Beach		
7 Parking lot		

ALKALINITY READING

Site	Va (Vol. Of acid used)	Ca (eq/L) 0.01 N (HCl)	Hf	VS (Sample Volume, ml)
Oddstad		0.01		100
North Fork		0.01		100
Linda Mar		0.01		100
Peralta		0.01		100
Outlet		0.01		100

HARDNESS

Site	A (amount of titrate used in mL)	Sample Volume
Oddstad		
North Fork		
Linda Mar		
Peralta		
Outlet		

Appendix 4
SAN PEDRO CREEK, PACIFICA, CA
SAMPLE HANDLING AND ANALYSIS PROTOCOL

- Stream site samples will be collected every Monday starting at 7:30 a.m. during the following months of the year 2,000:

- January 24 – February 22
- April 24– May 22
- July 17– August 14
- October 23– November 20

- Seven (7) sites will be sampled in this following order: Oddstad bridge, North fork (behind the Park Mall in the Valley), Linda Mar bridge (upstream from bridge, east side), Peralta bridge (downstream approx. 100' south side), in front of the parking lot at Linda Mar State beach (in ocean), the San Pedro Creek outlet, and in front of the San Pedro Creek outlet in the ocean.

Gearing up

A number of steps should be taken days before of the sampling day to ensure that all the equipment is in the vehicle.

Check List

- Field Collection Data Sheet
- Pen (2)
- Sampling bottles with sodium thiosulfate ($\text{Na}_2\text{S}_2\text{O}_3$)
- Labels
- Gloves
- Ice chests (3)
- Ice
- Blue ice
- Field notebook
- pHmeter (Fisher Scientific accumet portable AP50)*
- Dissolved oxygen meter (YSI Models 54 ARC and 54 ABP) * - City of Pacifica Waste Water Treatment Plant.
- Flow meter
- Zip-loc bags
- Permanent marker
- City of Pacifica vests (3)
- Thermometer
- Chest waders
- Dry clothes

- . Rope
- . Distilled water
- . Conductivity meter (Fisher Scientific accumet portable AP50)*

* Calibrate at the start of each sampling day.

1. Notify the EPA lab of the intent to sample. They are open Monday – Friday 8 am to 5 p.m. Call Andy Lincoff at 510 – 412-2330.
2. Go to the EPA lab (EPA Region 9 Lab 1337 S. 46th Street Building 201. Richmond, CA 94804) and pick up sterile bacteriologic sample bottles (100 ml), labels, and the chain of custody record.
3. Notify the San Mateo County Health Department of the intent to sample. Call Steven Hartcell at 650 – 363 – 4798. Go to La Calera Treatment Plant (700 Coast Highway –La Calera Creek Treatment Plant-3rd floor, Pacifica, CA) to pick up the San Mateo County Health Department sterile bacteriologic sample bottles (100 ml), labels, and bacteriological examination of water data sheet. Ask for Susan Tahaxson (650 – 738 - 4666).
4. Notify the Sequoia Lab of the intent to sample. They are open Monday – Friday 8 am to 5 p.m. Call Wayne Stevenson at (650)232-9600. Pick up the bottles for sampling.
5. Notify Susan Tahaxson of the need to use the DO meter the following Monday.
6. Go to the San Francisco State University map library (located in front of the room HSS 290). Ask Sara Marcellino for the air thermometer.
7. The day before the sampling day buy ice and put it into the ice chest to preserve it.
8. Label the bottles (EPA bottles, San Mateo County Health Department and the Sequoia Lab bottles based on their recommendations).
9. Check the weather conditions of the day before the sampling day. Record the information in the field collection data sheet.
<http://www.weather.com/weather/us/zips/94127.html>

Sampling Day

- Prior to leaving for the field

1. Calibrate the equipment -pHmeter and conductivitymeter- using the standard solutions.
2. Check weather conditions <http://www.weather.com/weather/us/zips/94127.html>
3. Check the check list. Be sure everything you need is in the vehicle.
4. At 7:15 a.m. go to the Pacifica Waste Water Treatment Plant (700 Coast Highway –La Calera Creek Treatment Plant-3rd floor, Pacifica, CA)
5. Go to the first sampling site (Oddstad).

In the Field

6. Upon arriving at the sample site, note the height of the water and general site conditions. Insure that the site can be safely sampled. Note general field conditions including time of day, rain/no rain, rising/falling branches, water color, runoff conditions, etc. Record.
7. Set the air thermometer.
8. Using chest waders and disposable rubber gloves get into the creek. Two (2) water samples should be taken at each sampling site (One for the EPA Lab and one for the San Mateo County Health Department). At Oddstad and North Fork sites samples should be taken for the Sequoia laboratory analyses. Use the following procedure to collect the bacteriologic and nutrient samples.
 - a. The EPA bottles have clear seals over their caps. Discard any sample bottle if its seal is broken.
 - b. To sample, remove the seal and cap being careful not to touch the inside of the cap bottle.
 - c. The EPA sample bottles may contain a small amount of a white powder (it is difficult to see) which will not interfere with the analysis. The white powder is Sodium thiosulfate ($\text{Na}_2\text{S}_2\text{O}_3$) which will neutralize residual chlorine, if present. The San Mateo County Health Department sample bottles contain a pill of the compound. Dip the bottle under water, mouth down, and with a slow forward sweeping motion turn bottle right side up and fill. The sample should be taken approximately six inches below the surface, but not deeper than one foot. Fill the bottle to the 100 ml line, leaving the space above the line empty. If the sample bottles is overfilled pour the excess out. If the cap becomes contaminated use a new bottle.

- d. Fill up the Sequoia Lab bottles in Oddstad and the North Fork. Do not dip the bottles in the water. They contain corrosive liquids. Fill up the bottles using a plastic glass.
 - e. Cap the bottles tightly and label them providing information such as date, time, sampler's name, and sample number. (NOTE: Include also test required and preservative).
9. Record the water and air temperature at each site. These temperatures should be read after one (1) minute in the medium.
10. Take the pH using the calibrated Fisher Scientific accumet portable AP50. Insert the probe into the water. Allow the level to stabilize before taking the reading. Record the pH in the field collection data sheet. (NOTE: Calibrate the equipment at the beginning of each sampling day using the instructions provided by the instrument's manual.) After each reading wash the probe with distilled water.
11. Take the conductivity using the calibrated Fisher Scientific accumet portable AP50. Insert the probe and allow the level to stabilize before taking the reading. Record the reading in the field collection data sheet (NOTE: Calibrate the equipment at the beginning of each sampling day using the instructions provided by the instrument's manual.) After each reading wash the probe with distilled water.
12. Take the dissolved oxygen (DO) level using the YSI Models 54 ARC and 54 ABP. The probe must be stirred rather vigorously to gain an accurate measurement. Read DO on appropriate range (0-10 or 0-20 mg/l). Once the fluctuation is less than 0.02 mg/l of oxygen take the reading (NOTE: Calibrate the equipment at the beginning of each sampling day using the instructions provided on the back part of the equipment.)
13. The discharge will be taken in Peralta using the flow-meter. Measure the depth and average velocity at the center of the creek. Record reading in the field collection data sheet.
14. The above steps should be performed at each of the seven (7) sampling sites. The field collection data sheet should be completed on site. Feel free to add any additional observations regarding site conditions, problems with the equipment, difficulties, etc.
15. Upon completion of sampling go to La Calera Treatment Plant give the sample bottles, the San Mateo County Health Department bacteriological examination water sheet and the Sequoia lab chain of custody to Susan Tahaxson. She will give the San Mateo County Health Department bottles to Matt Lindsey, and the

Sequoia Lab bottles and Chain of custody to the person from the Sequoia Lab in charge of picking up the bottles.

16. Afterwards, go to the EPA lab (EPA Region 9 Lab 1337 S. 46th Street Building 201 Richmond, CA 94804) and drop off the EPA sample bottles and the chain of custody records already completed. The samples must be at the lab by 2 p.m. Ask Andy Lincoff for more sample bottles, labels and the chain of custody records for next Monday.
17. When finished, go back to the Pacifica Waste Water Treatment Plant. Measure the turbidity, hardness and alkalinity. Use the MONITEK TA1 Nephelometer, the EDTA Titrimetric Method to measure turbidity. Ask Susan for the equipment instructions. Record the readings in the collection field data sheet.
18. To measure alkalinity use the following procedure recommended by Barnes (1964):

ALKALINITY TITRATION INSTRUCTIONS

1. Calibrate pH meter with pH 4 and 7 buffer.
2. Take 100 mL of water sample.
3. Insert pH probe and read the water sample pH
4. Run in HCl (approx 0.01 N) until the pH meter shows a stable reading of between pH 3 & 4.
5. Read final pH and amount of acid used.
6. Calculate alkalinity by

$$\text{Alk (m-eq/L)} = \frac{V_a C_a - H_f(V_a + V_s)}{V_s} \times 1000$$

where

V_a = vol. acid used (mL)

C_a = conc. acid used (eq/L)

H_f = final pH

V_s = sample volume (mL)

19. To measure hardness use the following procedure recommended by Clesceri *et al* (1995):

HARDNESS TITRATION INSTRUCTIONS

1. Take 25 mL of the water sample and dilute it to 50 mL with distilled water.
2. Add 2mL of buffer solution and two drops of the hardness indicator.
3. Titrate with the EDTA titrant solution to a blue-end point.
4. Use the following formula to calculate hardness:

$$\text{Hardness (mg CaCO}_3\text{ /L)} = \frac{A \times 1000}{\text{mL of sample}}$$

where A is the total amount of titrate used in mL.

Appendix 5. General Physical Field Conditions

DATE	SITE	TIME (am)	AIR TEMP. (C)	WEATHER CONDITIONS	WEATHER CONDITIONS	GENERAL FIELD CONDITIONS	TIDES	RAIN (Inches)
				Day before sampling	Sampling day			
01-24-00	Oddstad		No Record	Rainy and windy day. More or less 12 degrees	Rainy day.	No Record	High: 2:22 a.m. 5.6 Low 7:34 a.m. 2.2 High 1:32 p.m. 5.9	3.63
01-24-00	Linda Mar		No Record	Rainy and windy day. More or less 12 degrees	Rainy day.	No Record	High: 2:22 a.m. 5.6 Low 7:34 a.m. 2.2	3.63
01-24-00	Peralta		No Record	Rainy and windy day. More or less 12 degrees	Rainy day.	No Record	High: 2:22 a.m. 5.6 Low 7:34 a.m. 2.2	3.63
01-24-00	Parking lot		No Record	Rainy and windy day. More or less 12 degrees	Rainy day.	No Record	High: 2:22 a.m. 5.6 Low 7:34 a.m. 2.2	3.63
01-24-00	Outlet		No Record	Rainy and windy day. More or less 12 degrees	Rainy day.	No Record	High: 2:22 a.m. 5.6 Low 7:34 a.m. 2.2	3.63
01-24-00	Beach		No Record	Rainy and windy day. More or less 12 degrees	Rainy day.	No Record	High: 2:22 a.m. 5.6 Low 7:34 a.m. 2.2 High 1:32 p.m. 5.9	3.63

Rainfall and tides information taken from the Pacifica Tribune

General Physical Field Conditions

DATE	SITE	TIME (am)	AIR TEMP. (C)	WEATHER CONDITIONS Day Before Sampling	WEATHER CONDITIONS Sampling day	GENERAL FIELD CONDITIONS	TIDES	RAIN (inches)
01-31-00	Oddstad	8:00	11.5	01-30-00. Partly cloudy no rain, some drizzle	Overcast. Drizzle	A Little bit windy. Creek had leaf follout, trunks,limbs, and some other natural	Low: 1:28 a.m. 2.9 High: 7:40 a.m. 5.8 Low 2:57 p.m.	0.05
01-31-00	N. Fork	8:35	12.0	01-30-00. Partly cloudy no rain, some drizzle	Overcast. Drizzle	Garbage (bottles, cans, papers) and even a supermarket car. I saw worms in the water. The smell of the place was like a rotten egg	Low: 1:28 a.m. 2.9 High: 7:40 a.m. 5.8 Low 2:57 p.m. 0,3 High 10: p.m. 4,4	0.05
01-31-00	Linda Mar	9:15	12.0	01-30-00. Partly cloudy no rain, some drizzle	Overcast. Drizzle	Clear water. Neither garbage notr big particules were present.	Low: 1:28 a.m. 2.9 High: 7:40 a.m. 5.8	0.05
01-31-00	Peralta	9:45	12.0	01-30-00. Partly cloudy no rain, some drizzle	Overcast. Drizzle	In the shore I found garbage such as a radio, plastic bottles and papers. Area with a lot of trees.	Low: 1:28 a.m. 2.9 High: 7:40 a.m. 5.8 Low 2:57 p.m.	0.05
01-31-00	Parking lot	10:00	13.0	01-30-00. Partly cloudy no rain, some drizzle	Overcast. Drizzle	The tide was high. The water was very cold	Low: 1:28 a.m. 2.9 High: 7:40 a.m. 5.8	0.05
01-31-00	Outlet	10:15	13.0	01-30-00. Partly cloudy no rain, some drizzle	Overcast. Drizzle	Because the tide was high, there was a mixture of the sea and creek water	Low: 1:28 a.m. 2.9 High: 7:40 a.m. 5.8 Low 2:57 p.m.	0.05
01-31-00	Beach	10:30	13.0	01-30-00. Partly cloudy no rain, some drizzle	Overcast. Drizzle	The tide was high. The water was very cold	Low: 1:28 a.m. 2.9 High: 7:40 a.m. 5.8 Low 2:57 p.m.	0.05

Rainfall and tides information taken from the Pacifica Tribune

Appendix 5. General Physical Field Conditions

DATE	SITE	TIME (am)	AIR TEMP. (C)	WEATHER CONDITIONS	WEATHER CONDITIONS	GENERAL FIELD CONDITIONS	TIDES	RAIN (Inches)
				Day Before Sampling	Sampling day			
02-07-00	Oddstad	8:52	13.0	02-06-00. 59 F. Wind calm,Dew point: 51F, Rel. Humidity75%, Visibility 10 miles	02-07-00. Foggy. 50 F. Wind chill 44F Wind from SE at 6 mph. Dew Point: 50F. Rel H: 100%. Visib: 1	Overcast sky. Creek is clear, water level is low. Easy to access to get samples.	High: 1:14 a.m 5.1 Low 6:15 a.m. 2,4 High 12:19 p. 5.8 Low 6:45 p.m. -0,1	No report
02-07-00	N. Fork	9:40	13.0	02-06-00. 59 F. Wind calm,Dew point: 51F, Rel. Humidity75%, Visibility 10 miles	02-07-00. Foggy. 50 F. Wind chill 44F Wind from SE at 6 mph. Dew Point: 50F. Rel H: 100%. Visib: 1	Overcast sky. Creek is clear, water level is low. Easy to access to get samples.	High: 1:14 a.m 5.1 Low 6:15 a.m. 2,4 High 12:19 p. 5.8 Low 6:45 p.m. -0,1	No report
02-07-00	Linda Mar	10:06	13.0	02-06-00. 59 F. Wind calm,Dew point: 51F, Rel. Humidity75%, Visibility 10 miles	02-07-00. Foggy. 50 F. Wind chill 44F Wind from SE at 6 mph. Dew Point: 50F. Rel H: 100%. Visib: 1	Overcast sky. Creek is clear, water level is low. Easy to access to get samples.	High: 1:14 a.m 5.1 Low 6:15 a.m. 2,4 High 12:19 p. 5.8 Low 6:45 p.m. -0,1	No report
02-07-00	Peralta	11:10	13.5	02-06-00. 59 F. Wind calm,Dew point: 51F, Rel. Humidity75%, Visibility 10 miles	02-07-00. Foggy. 50 F. Wind chill 44F Wind from SE at 6 mph. Dew Point: 50F. Rel H: 100%. Visib: 1	Overcast sky. Creek is clear, water level is low. Easy to access to get samples.	High: 1:14 a.m 5.1 Low 6:15 a.m. 2,4 High 12:19 p. 5.8 Low 6:45 p.m. -0,1	No report
02-07-00	Outlet	11:30	13.5	02-06-00. 59 F. Wind calm,Dew point: 51F, Rel. Humidity75%, Visibility 10 miles	02-07-00. Foggy. 50 F. Wind chill 44F Wind from SE at 6 mph. Dew Point: 50F. Rel H: 100%. Visib: 1	Overcast sky. Creek is clear, water level is low. Easy to access to get samples.	High: 1:14 a.m 5.1 Low 6:15 a.m. 2,4 High 12:19 p. 5.8 Low 6:45 p.m. -0,1	No report
02-07-00	Parking lot	11:40	13.5	02-06-00. 59 F. Wind calm,Dew point: 51F, Rel. Humidity75%, Visibility 10 miles	02-07-00. Foggy. 50 F. Wind chill 44F Wind from SE at 6 mph. Dew Point: 50F. Rel H: 100%. Visib: 1	Overcast sky. Creek is clear, water level is low. Easy to access to get samples.	High: 1:14 a.m 5.1 Low 6:15 a.m. 2,4 High 12:19 p. 5.8 Low 6:45 p.m. -0,1	No report
02-07-00	Beach	12:50	16.5	02-06-00. 59 F. Wind calm,Dew point: 51F, Rel. Humidity75%, Visibility 10 miles	02-07-00. Foggy. 50 F. Wind chill 44F Wind from SE at 6 mph. Dew Point:	Overcast sky. Creek is clear, water level is low. Easy to access to get samples.	High: 1:14 a.m 5.1 Low 6:15 a.m. 2,4 High 12:19 p. 5.8	No report

Rainfall and tides information taken from the Pacifica Tribune

General Physical Field Conditions

DATE	SITE	TIME (am)	AIR TEMP. (C)	WEATHER CONDITIONS	WEATHER CONDITIONS	GENERAL FIELD CONDITIONS	TIDES (feet)	RAIN (Inches)
				Day Before Sampling	Sampling day			
02-14-00	Oddstad	8:40	14.0	59 F. Wind from SE at 7mph. Dew point: 57 F. Rel H: 93% Visibility: 5 miles. Barometer:29.82 inches	Light rain. 55F Wind from S 14 mph. Dewpoint: 53F. Rel H: 93% Visibility 6 miles	Stream was flowing rapidly Storming hard last 2 days. Water has created banks from	No report	1.61
02-14-00	N. Fork	8:50	14.0	59 F. Wind from SE at 7mph. Dew point: 57 F. Rel H: 93% Visibility: 5 miles. Barometer:29.82 inches	Light rain. 55F Wind from S 14 mph. Dewpoint: 53F. Rel H: 93% Visibility 6 miles	Impossible to stand up where the concrete columns are infront of the culvert.	No report	1.61
02-14-00	Linda Mar	9:35	14.0	59 F. Wind from SE at 7mph. Dew point: 57 F. Rel H: 93% Visibility: 5 miles. Barometer:29.82 inches	Light rain. 55F Wind from S 14 mph. Dewpoint: 53F. Rel H: 93% Visibility 6 miles	Current much stronger at this location. Water level very high. Impossible	No report	1.61
02-14-00	Peralta	10:10	14.0	59 F. Wind from SE at 7mph. Dew point: 57 F. Rel H: 93% Visibility: 5 miles. Barometer:29.82 inches	Light rain. 55F Wind from S 14 mph. Dewpoint: 53F. Rel H: 93% Visibility 6 miles	Water was highand fast making impossible to use flow meter.	No report	1.61
02-14-00	Outlet	12:00	15.0	59 F. Wind from SE at 7mph. Dew point: 57 F. Rel H: 93% Visibility: 5 miles. Barometer:29.82 inches	Light rain. 55F Wind from S 14 mph. Dewpoint: 53F. Rel H: 93% Visibility 6 miles	Channel narrow and swift at outlet.	No report	1.61
02-14-00	Parking lot	12:10	15.0	59 F. Wind from SE at 7mph. Dew point: 57 F. Rel H: 93% Visibility: 5 miles. Barometer:29.82 inches	Light rain. 55F Wind from S 14 mph. Dewpoint: 53F. Rel H: 93% Visibility 6 miles	Strong waves, windy	No report	1.61
02-14-00	Beach	12:20	15.0	59 F. Wind from SE at 7mph. Dew point: 57 F. Rel H: 93% Visibility: 5 miles. Barometer:29.82 inches	Light rain. 55F Wind from S 14 mph. Dewpoint: 53F. Rel H: 93% Visibility 6 miles	A lot of sediments was brought by the outlet	No report	1.61

Rainfall and tides information taken from the Pacifica Tribune

Appendix 5. General Physical Field Conditions

DATE	SITE	TIME (am)	AIR TEMP. (C)	WEATHER CONDITIONS Day Before Sampling	WEATHER CONDITIONS Sampling day	GENERAL FIELD CONDITIONS	TIDES (feet)	RAIN (Inches)
02-22-00	Oddstad	7:45	12.0	59F Mostly sunny. Wind from N at 9 mph. Dew Point 50F. Rel H: 72%. Visibility: 10miles. Barometer 29,84 inches	Cloudy. 54F. Wind from East 9mph Dewpoint: 48F. Rel H: 80%. Barometer:30,06 inches	Water very clear. Lower water level compare to last week. Very windy	High 1:36 a.m. 5.7 Low 7:10 a.m. 1.4 High 1:21 p.m. 5.5 Low 7:25 p.m. 0,5	0.23
02-22-00	N. Fork	8:15	13.0	59F Mostly sunny. Wind from N at 9 mph. Dew Point 50F. Rel H: 72%. Visibility: 10miles. Barometer 29,84 inches	Cloudy. 54F. Wind from East 9mph Dewpoint: 48F. Rel H: 80%. Barometer:30,06 inches	Strong bad. Lots of worms in the water close to the tunnel. Foam in the right side of the sampling site. Garbage like paper glasses, plastics, etc.	High 1:36 a.m. 5.7 Low 7:10 a.m. 1.4 High 1:21 p.m. 5.5 Low 7:25 p.m. 0,5	0.23
02-22-00	Linda Mar	8:40	12.5	59F Mostly sunny. Wind from N at 9 mph. Dew Point 50F. Rel H: 72%. Visibility: 10miles. Barometer 29,84 inches	Cloudy. 54F. Wind from East 9mph Dewpoint: 48F. Rel H: 80%. Barometer:30,06 inches	Width of the creek less than half compared to last week. Gravel in the middle of the creek. Lots of sediments. The creek did not meander. Bank. Upstream sampling site	High 1:36 a.m. 5.7 Low 7:10 a.m. 1.4 High 1:21 p.m. 5.5 Low 7:25 p.m. 0,5	0.23
02-22-00	Peralta	9:45	13.0	59F Mostly sunny. Wind from N at 9 mph. Dew Point 50F. Rel H: 72%. Visibility: 10miles. Barometer 29,84 inches	Cloudy. 54F. Wind from East 9mph Dewpoint: 48F. Rel H: 80%. Barometer:30,06 inches	Water very clear. Discharge measurement was easy to take. Low Water level .	High 1:36 a.m. 5.7 Low 7:10 a.m. 1.4 High 1:21 p.m. 5.5 Low 7:25 p.m. 0,5	0.23
02-22-00	Outlet	10:40	13.5	59F Mostly sunny. Wind from N at 9 mph. Dew Point 50F. Rel H: 72%. Visibility: 10miles. Barometer 29,84 inches	Cloudy. 54F. Wind from East 9mph Dewpoint: 48F. Rel H: 80%. Barometer:30,06 inches	Water flow straight. Clear water, low flow	High 1:36 a.m. 5.7 Low 7:10 a.m. 1.4 High 1:21 p.m. 5.5 Low 7:25 p.m. 0,5	0.23
02-22-00	Parking lot	11:00	13.5	59F Mostly sunny. Wind from N at 9 mph. Dew Point 50F. Rel H: 72%. Visibility: 10miles. Barometer 29,84 inches	Cloudy. 54F. Wind from East 9mph Dewpoint: 48F. Rel H: 80%. Barometer:30,06 inches	High waves, very windy, and high tide.	High 1:36 a.m. 5.7 Low 7:10 a.m. 1.4 High 1:21 p.m. 5.5 Low 7:25 p.m. 0,5	0.23
02-22-00	Beach	10:50	13.5	59F Mostly sunny. Wind from N at 9 mph. Dew Point 50F. Rel H: 72%. Visibility: 10miles. Barometer 29,84 inches	Cloudy. 54F. Wind from East 9mph Dewpoint: 48F. Rel H: 80%. Barometer:30,06 inches	High waves, very windy, and high tide.	High 1:36 a.m. 5.7 Low 7:10 a.m. 1.4 High 1:21 p.m. 5.5 Low 7:25 p.m. 0,5	0.23

Rainfall and tides information taken from the Pacifica Tribune

Appendix 5. General Physical Field Conditions

DATE	SITE	TIME (am)	AIR TEMP.	WEATHER CONDITIONS	WEATHER CONDITIONS	GENERAL FIELD CONDITIONS	TIDES (feet)	RAIN (Inches)
				Day Before Sampling	Sampling day			
02-28-00	Oddstad	7:40	11.0	Cloudy. 52F. Wind from the W at 13 mph. Dewpoint 45F. Rel.H: 77% Visibility: 10miles. Barom: 29.96 inches	Partly cloudy. 50F. Wind chill 33F from the W at 14 mph. Dewpoint: 45F. Rel.H: 83%. Visibility: 10 miles	More flow than last week. Deeper than last week. Creek has eroded or dug out more. Warmer than last week. It	Low 12:00 a.m. 3.0 High 6:00 a.m. 5.2 Low 1:14 p.m. 0.7 High 8:45 p.m. 4.2	0.00
02-28-00	N. Fork	8:07	12.0	Cloudy. 52F. Wind from the W at 13 mph. Dewpoint 45F. Rel.H: 77% Visibility: 10miles. Barom: 29.96 inches	Partly cloudy. 50F. Wind chill 33F from the W at 14 mph. Dewpoint: 45F. Rel.H: 83%. Visibility: 10 miles	More flow. I couldn't stand next to the pipe. Evident foam-the left side of the sampling site. oil film on surface. NO worms at	Low 12:00 a.m. 3.0 High 6:00 a.m. 5.2 Low 1:14 p.m. 0.7 High 8:45 p.m. 4.2	0.00
02-28-00	Linda Mar	8:35	12.0	Cloudy. 52F. Wind from the W at 13 mph. Dewpoint 45F. Rel.H: 77% Visibility: 10miles. Barom: 29.96 inches	Partly cloudy. 50F. Wind chill 33F from the W at 14 mph. Dewpoint: 45F. Rel.H: 83%. Visibility: 10 miles	Flow is moderate to high. Gravel on right bank. Lots of debris. Wood along the banks suggesting the level was higher sometime last week.	Low 12:00 a.m. 3.0 High 6:00 a.m. 5.2 Low 1:14 p.m. 0.7 High 8:45 p.m. 4.2	0.00
02-28-00	Peralta	9:00	14.0	Cloudy. 52F. Wind from the W at 13 mph. Dewpoint 45F. Rel.H: 77% Visibility: 10miles. Barom: 29.96 inches	Partly cloudy. 50F. Wind chill 33F from the W at 14 mph. Dewpoint: 45F. Rel.H: 83%. Visibility: 10 miles	Water level higher than last week. Difficulty measuring discharge. Turbid water. Lots of sediments flowing (tree limbs).	Low 12:00 a.m. 3.0 High 6:00 a.m. 5.2 Low 1:14 p.m. 0.7 High 8:45 p.m. 4.2	0.00
02-28-00	Outlet	10:05	13.5	Cloudy. 52F. Wind from the W at 13 mph. Dewpoint 45F. Rel.H: 77% Visibility: 10miles. Barom: 29.96 inches	Partly cloudy. 50F. Wind chill 33F from the W at 14 mph. Dewpoint: 45F. Rel.H: 83%. Visibility: 10 miles	Stream is narrower than last week. Evident foam close to the beach.	Low 12:00 a.m. 3.0 High 6:00 a.m. 5.2 Low 1:14 p.m. 0.7 High 8:45 p.m. 4.2	0.00
02-28-00	Parking lot	10:25	13.5	Cloudy. 52F. Wind from the W at 13 mph. Dewpoint 45F. Rel.H: 77% Visibility: 10miles. Barom: 29.96 inches	Partly cloudy. 50F. Wind chill 33F from the W at 14 mph. Dewpoint: 45F. Rel.H: 83%. Visibility: 10 miles	Lots of foam on the beach, near the the outlet. Tide looks lower than last week.	Low 12:00 a.m. 3.0 High 6:00 a.m. 5.2 Low 1:14 p.m. 0.7 High 8:45 p.m. 4.2	0.00
02-28-00	Beach	10:20	13.5	Cloudy. 52F. Wind from the W at 13 mph. Dewpoint 45F. Rel.H: 77% Visibility: 10miles. Barom: 29.96 inches	Partly cloudy. 50F. Wind chill 33F from the W at 14 mph. Dewpoint: 45F. Rel.H: 83%. Visibility: 10 miles	Lots of foam on the beach, near the the outlet. Tide looks lower than last week.	Low 12:00 a.m. 3.0 High 6:00 a.m. 5.2 Low 1:14 p.m. 0.7 High 8:45 p.m. 4.2	0.00

Rainfall and tides information taken from the Pacifica Tribune

Appendix 5. General Physical Field Conditions

DATE	SITE	TIME (am)	AIR TEMP.	WEATHER CONDITIONS	WEATHER CONDITIONS	GENERAL FIELD CONDITIONS	TIDES (feet)	RAIN (Inches)
				Day Before Sampling	Sampling day			
04-24-00	Oddstad	7:40	11.0	04-23-00.57 F. Wind 24 mph from the W. Dew point 43 F. Rel H: 59%, Visib: 10 miles. Barom: 30.22"	04-24-00. 48 F. Wind chill 39F 7 mph from the W. Dew point 45F. Rel H: 89%. Visib: 10 miles. Barom: 30.17"	Low water level. Not covering sampling point. Clear water, branches and rocks. There is a bank in the sampling site. White-brown foam.	No report	No rain
04-24-00	N. Fork	8:30	15.0	04-23-00.57 F. Wind 24 mph from the W. Dew point 43 F. Rel H: 59%, Visib: 10 miles. Barom: 30.22"	04-24-00. 48 F. Wind chill 39F 7 mph from the W. Dew point 45F. Rel H: 89%. Visib: 10 miles. Barom: 30.17"	Water end of the culvert running 1/2 width. Foam near shore area. Lots of garbage (paper, bottles). Muddy slim. Smell not as bad as it was in the past. Clear possible to see bottom of the creek.	No report	No rain
04-24-00	Linda Mar	9:10	14.5	04-23-00.57 F. Wind 24 mph from the W. Dew point 43 F. Rel H: 59%, Visib: 10 miles. Barom: 30.22"	04-24-00. 48 F. Wind chill 39F 7 mph from the W. Dew point 45F. Rel H: 89%. Visib: 10 miles. Barom: 30.17"	Back eddy with stillwater. Sampling on left bank that weren't there last time. Tree roots exposed. Clear water. Creek flowing half width of the	No report	No rain
04-24-00	Peralta	10:35	16.0	04-23-00.57 F. Wind 24 mph from the W. Dew point 43 F. Rel H: 59%, Visib: 10 miles. Barom: 30.22"	04-24-00. 48 F. Wind chill 39F 7 mph from the W. Dew point 45F. Rel H: 89%. Visib: 10 miles. Barom: 30.17"	Mosquitos. Water level very low. Water not covering tree roots where "measuring string" is attached	No report	No rain
04-24-00	Outlet	11:33	15.0	04-23-00.57 F. Wind 24 mph from the W. Dew point 43 F. Rel H: 59%, Visib: 10 miles. Barom: 30.22"	04-24-00. 48 F. Wind chill 39F 7 mph from the W. Dew point 45F. Rel H: 89%. Visib: 10 miles. Barom: 30.17"	Flow of the creek toward South. Very narrow. More debris (branches, rocks) Sediments on the rocks-brown	No report	No rain
04-24-00	Beach	11:45	14.5	04-23-00.57 F. Wind 24 mph from the W. Dew point 43 F. Rel H: 59%, Visib: 10 miles. Barom: 30.22"	04-24-00. 48 F. Wind chill 39F 7 mph from the W. Dew point 45F. Rel H: 89%. Visib: 10 miles. Barom: 30.17"	Low ride. Moss on beach rocks. Lots of jelly fish in the beach	No report	No rain
04-24-00	Parking lot	11:55	14.5	04-23-00.57 F. Wind 24 mph from the W. Dew point 43 F. Rel H: 59%, Visib: 10 miles. Barom: 30.22"	04-24-00. 48 F. Wind chill 39F 7 mph from the W. Dew point 45F. Rel H: 89%. Visib: 10 miles. Barom: 30.17"	Lots of cobbles on beach	No report	No rain

Rainfall and tides information taken from the Pacifica Tribune

General Physical Field Conditions

DATE	SITE	TIME	AIR TEMP. (C)	WEATHER CONDITIONS	WEATHER CONDITIONS	GENERAL FIELD CONDITIONS	TIDES (feet)	RAIN (inches)
05-01-00	Oddslad	7:45	13.5	04:30-00. Sunny and windy. 55F 22mph from the W. Dew point: 43F. Rel. H: 64% Visib: 10 miles Barom: 30.10"	Partly cloudy. 52F. 15mph 46F. Rel H: 80%. Visib: 10 miles Barom: 30.08"	Undercutting visible, lots of debris, water running clear. Lots of Eucalyptus leaves and seeds. Banana slugs. The creek's width is narrower than last Monday.	4:20 .m. Low: 0.9 10:34 a.m. High: 4.74:13 p.m. Low: 0.7 10:50 p.m. High: 5.6	No rain
05-01-00	N. Fork	8:30	14.5	04:30-00. Sunny and windy. 55F 22mph from the W. Dew point: 43F. Rel. H: 64% Visib: 10 miles Barom: 30.10"	Partly cloudy. 52F. 15mph 46F. Rel H: 80%. Visib: 10 miles Barom: 30.08"	Small brown warms present Rotten smell. Water more clear than last time with not as much foam present.	4:20 .m. Low: 0.9 10:34 a.m. High: 4.74:13 p.m. Low: 0.7 10:50 p.m. High: 5.6	No rain
05-01-00	Linda Mar	9:00	15.0	04:30-00. Sunny and windy. 55F 22mph from the W. Dew point: 43F. Rel. H: 64% Visib: 10 miles Barom: 30.10"	Partly cloudy. 52F. 15mph 46F. Rel H: 80%. Visib: 10 miles Barom: 30.08"	Creek relatively clear, more straight than last time. Lots of Eucalyptus capsules. Not as much debris as in N. Fork	4:20 .m. Low: 0.9 10:34 a.m. High: 4.74:13 p.m. Low: 0.7 10:50 p.m. High: 5.6	No rain
05-01-00	Petalta	9:30	17.0	04:30-00. Sunny and windy. 55F 22mph from the W. Dew point: 43F. Rel. H: 64% Visib: 10 miles Barom: 30.10"	Partly cloudy. 52F. 15mph 46F. Rel H: 80%. Visib: 10 miles Barom: 30.08"	Water flow not as much as a week ago. Clear water. There was a bank in the right hand side of the sampling point.	4:20 .m. Low: 0.9 10:34 a.m. High: 4.74:13 p.m. Low: 0.7 10:50 p.m. High: 5.6	No rain
05-01-00	Outlet	10:25	18.0	04:30-00. Sunny and windy. 55F 22mph from the W. Dew point: 43F. Rel. H: 64% Visib: 10 miles Barom: 30.10"	Partly cloudy. 52F. 15mph 46F. Rel H: 80%. Visib: 10 miles Barom: 30.08"	Creek water curves to smooth, always, by a brown sediment. Water moved very slowly	4:20 .m. Low: 0.9 10:34 a.m. High: 4.74:13 p.m. Low: 0.7 10:50 p.m. High: 5.6	No rain
05-01-00	Beach	10:30	16.0	04:30-00. Sunny and windy. 55F 22mph from the W. Dew point: 43F. Rel. H: 64% Visib: 10 miles Barom: 30.10"	Partly cloudy. 52F. 15mph 46F. Rel H: 80%. Visib: 10 miles Barom: 30.08"	Little wind. Ocean water barely reaches the creek	4:20 .m. Low: 0.9 10:34 a.m. High: 4.74:13 p.m. Low: 0.7 10:50 p.m. High: 5.6	No rain
05-01-00	Parking lot	10:40	15.0	04:30-00. Sunny and windy. 55F 22mph from the W. Dew point: 43F. Rel. H: 64% Visib: 10 miles Barom: 30.10"	Partly cloudy. 52F. 15mph 46F. Rel H: 80%. Visib: 10 miles Barom: 30.08"	Rip tide present. Lots of crabs' part on the beach	4:20 .m. Low: 0.9 10:34 a.m. High: 4.74:13 p.m. Low: 0.7 10:50 p.m. High: 5.6	No rain

Rainfall and tides information taken from the Pacifica Tribune

Appendix 5. General Physical Field Conditions

DATE	SITE	TIME (am)	AIR TEMP. (C)	WEATHER CONDITIONS Day Before Sampling	WEATHER CONDITIONS Sampling day	GENERAL FIELD CONDITIONS	TIDES (feet)	RAIN (Inches)
05-09-00	Oddstad	7:40	15.0	05-08-00. Mostly sunny. 55F. Windy, 20 mph from W. Dew Point: 52F. Rel H: 90%, Visib: 10 miles. Barom: 30,12"	Cloudy. 55F. 9 mph from W. Dew Point: 48 F. Rel H: 77% Visib: 10 miles. Barom: 30,11"	Up sampling site a tree fell down. Lots of debris and branches. Creek flow very narrow. Water not circulating very well because of branches and the tree "pond". Lots of Eucalypts seeds.	Low: 5,6 10:45 a.m. High: -0,9 6:23 p.m. Low: 4,8 11:18 p.m. High: 2,7	No rain
05-09-00	N. Fork	8:15	15.2	05-08-00. Mostly sunny. 55F. Windy, 20 mph from W. Dew Point: 52F. Rel H: 90%, Visib: 10 miles. Barom: 30,12"	Cloudy. 55F. 9 mph from W. Dew Point: 48 F. Rel H: 77% Visib: 10 miles. Barom: 30,11"	Worms were collected. Odor coming from the culvert. Lots of garbage (color balls, plastoc bottles, plastic gloves). Foam around edges. Slime on rocks.	Low: 5,6 10:45 a.m. High: -0,9 6:23 p.m. Low: 4,8 11:18 p.m. High: 2,7	No rain
05-09-00	Linda Mar	8:45	15.0	05-08-00. Mostly sunny. 55F. Windy, 20 mph from W. Dew Point: 52F. Rel H: 90%, Visib: 10 miles. Barom: 30,12"	Cloudy. 55F. 9 mph from W. Dew Point: 48 F. Rel H: 77% Visib: 10 miles. Barom: 30,11"	More flow than last week due to rain on Monday. Flow from the North cuts left and there quickly right. Roots along bank exposed. Mild Eucalyptus smell. Some garbage around.	Low: 5,6 10:45 a.m. High: -0,9 6:23 p.m. Low: 4,8 11:18 p.m. High: 2,7	No rain
05-09-00	Peralta	9:05	15.0	Mostly sunny. 55F. Windy, 20 mph from W. Dew Point: 52F. Rel H: 90%, Visib: 10 miles. Barom: 30,12"	Cloudy. 55F. 9 mph from W. Dew Point: 48 F. Rel H: 77% Visib: 10 miles. Barom: 30,11"	Less flow. Substrate more sandy, Clear water. Some fish +/- 2 inches long.	Low: 5,6 10:45 a.m. High: -0,9 6:23 p.m. Low: 4,8 11:18 p.m. High: 2,7	No rain
05-09-00	Outlet	9:55	18.0	Mostly sunny. 55F. Windy, 20 mph from W. Dew Point: 52F. Rel H: 90%, Visib: 10 miles. Barom: 30,12"	Cloudy. 55F. 9 mph from W. Dew Point: 48 F. Rel H: 77% Visib: 10 miles. Barom: 30,11"	Low flow. Large chunks of wood scattered. Low tide exposing rocks (with algae) never seen before. Brown sediment on bottom of the creek. Creek bends left and the straight to ocean.	Low: 5,6 10:45 a.m. High: -0,9 6:23 p.m. Low: 4,8 11:18 p.m. High: 2,7	No rain
05-09-00	Beach	10:05	18.0	Mostly sunny. 55F. Windy, 20 mph from W. Dew Point: 52F. Rel H: 90%, Visib: 10 miles. Barom: 30,12"	Cloudy. 55F. 9 mph from W. Dew Point: 48 F. Rel H: 77% Visib: 10 miles. Barom: 30,11"	Low tide. Lots of rocks in the beach. Clear water.	Low: 5,6 10:45 a.m. High: -0,9 6:23 p.m. Low: 4,8 11:18 p.m. High: 2,7	No rain
05-09-00	Parking lot	10:10	18.0	Mostly sunny. 55F. Windy, 20 mph from W. Dew Point: 52F. Rel H: 90%, Visib: 10 miles. Barom: 30,12"	Cloudy. 55F. 9 mph from W. Dew Point: 48 F. Rel H: 77% Visib: 10 miles. Barom: 30,11"	Clear water, lots of birds eating algae from exposed rock	Low: 5,6 10:45 a.m. High: -0,9 6:23 p.m. Low: 4,8 11:18 p.m. High: 2,7	No rain

Rainfall and tides information taken from the Pacifica Tribune

Appendix 5. General Physical Field Conditions

DATE	SITE	TIME (am)	AIR TEMP. (C)	WEATHER CONDITIONS	WEATHER CONDITIONS	GENERAL FIELD CONDITIONS	TIDES (feet)	RAIN (Inches)
				Day Before Sampling	Sampling day			
05-15-00	Oddstad	7:40	14.5	Rainy. 59F. Wind 17 mph from East. Dew point: 48F. RelH: 67%. Visib: 10 miles	Light rain. 55F. Wind 3 mph from South. Dew point: 52F. Rel H: 90%. Visib: 9 miles. Barom: 0.00". Hi: 57 and lo: 49F	Water is clear. A lot of debris building up by test area. Water level about same as last week. Strong Eucalyptus smell.	4:33 a.m. Low: 0,2 10:58 a.m. High:4,5 4:15p.m. High: 1,2 10:52 p.m.High:5,9	No rain
05-15-00	N. Fork	8:10	17.0	Rainy. 59F. Wind 17 mph from East. Dew point: 48F. RelH: 67%. Visib: 10 miles	Light rain. 55F. Wind 3 mph from South. Dew point: 52F. Rel H: 90%. Visib: 9 miles. Barom: 0.00". Hi: 57 and lo: 49F	Bad smell coming from culvert and surrounding area. Lots of debris and garbage collecting around culvert entrance. Dripping noise coming from the culvert. Possible to see algae covering exposed	4:33 a.m. Low: 0,2 10:58 a.m. High:4,5 4:15p.m. High: 1,2 10:52 p.m.High:5,9	No rain
05-15-00	Linda Mar	8:35	17.0	Rainy. 59F. Wind 17 mph from East. Dew point: 48F. RelH: 67%. Visib: 10 miles	Light rain. 55F. Wind 3 mph from South. Dew point: 52F. Rel H: 90%. Visib: 9 miles. Barom: 0.00". Hi: 57 and lo: 49F	Stream is a bit deeper compared with last week. The flow is greater, and a bit wider. 3-7" coble rocks. Two riffles in between sampling site	4:33 a.m. Low: 0,2 10:58 a.m. High:4,5 4:15p.m. High: 1,2 10:52 p.m.High:5,9	No rain
05-15-00	Peralta	9:00	16.0	Rainy. 59F. Wind 17 mph from East. Dew point: 48F. RelH: 67%. Visib: 10 miles	Light rain. 55F. Wind 3 mph from South. Dew point: 52F. Rel H: 90%. Visib: 9 miles. Barom: 0.00". Hi: 57 and lo: 49F	Lots of mosquitos. Water appears muddier. Less flow. Riffle behind sampling area (downstream). Foam coming from upstream which got dissolved before reaching sampling point	4:33 a.m. Low: 0,2 10:58 a.m. High:4,5 4:15p.m. High: 1,2 10:52 p.m.High:5,9	No rain
05-15-00	Outlet	9:40	21.0	Rainy. 59F. Wind 17 mph from East. Dew point: 48F. RelH: 67%. Visib: 10 miles	Light rain. 55F. Wind 3 mph from South. Dew point: 52F. Rel H: 90%. Visib: 9 miles. Barom: 0.00". Hi: 57 and lo: 49F	bottom. Lots of debris (fire extinguisher) and wood. Starighter channel, high tide.Green algae covering rocks. Foam around some rocks	4:33 a.m. Low: 0,2 10:58 a.m. High:4,5 4:15p.m. High: 1,2 10:52 p.m.High:5,9	No rain
05-15-00	Beach	9:50	18.0	Rainy. 59F. Wind 17 mph from East. Dew point: 48F. RelH: 67%. Visib: 10 miles	Light rain. 55F. Wind 3 mph from South. Dew point: 52F. Rel H: 90%. Visib: 9 miles. Barom: 0.00". Hi: 57 and lo: 49F	Lots of debris, and garbage offshore breeze.	4:33 a.m. Low: 0,2 10:58 a.m. High:4,5 4:15p.m. High: 1,2 10:52 p.m.High:5,9	No rain
05-15-00	Parking lot	9:55	18.0	Rainy. 59F. Wind 17 mph from East. Dew point: 48F. RelH: 67%. Visib: 10 miles	Light rain. 55F. Wind 3 mph from South. Dew point: 52F. Rel H: 90%. Visib: 9 miles. Barom: 0.00". Hi: 57 and lo: 49F	Wave were breaking close to shore. High breeze. Lots of cobble on the beach.	4:33 a.m. Low: 0,2 10:58 a.m. High:4,5 4:15p.m. High: 1,2 10:52 p.m.High:5,9	No rain

Rainfall and tides information taken from the Pacifica Tribune

Appendix 5. General Physical Field Conditions

DATE	SITE	TIME (am)	AIR TEMP.	WEATHER CONDITIONS	WEATHER CONDITIONS	GENERAL FIELD CONDITIONS	TIDES (feet)	RAIN (Inches)
				Day Before Sampling	Sampling day			
05-22-00	Oddstad	7:40	15.0	Sunny. 69F Winds from W 6 mph. Dew Point: 59F. Rel H: 70%. Visib: 7 miles. Barom: 29.97" Hi: 74F, Lo: 54F	Mostly sunny. 58F Wind from W 3 mph. Dew Point: 51F. relH: 77%. Visib: 9 miles. Barom: 29.87". Hi: 77F Lo 58 F	Eucalyptus smell. Lots of eucalyptus leaves and seeds. Banks severely undercut. North side of bank roots were exposed. Small edie in sampling site. Lots of mosquitos. Clear water	2:00a.m. Low:5,2 8:55 a.m.High:-0,4 4:36 p.m.Low: 4,3 9:05 p.m. High:3,2	No rain
05-22-00	N. Fork	8:05	17.0	Sunny. 69F Winds from W 6 mph. Dew Point: 59F. Rel H: 70%. Visib: 7 miles. Barom: 29.97" Hi: 74F, Lo: 54F	Mostly sunny. 58F Wind from W 3 mph. Dew Point: 51F. relH: 77%. Visib: 9 miles. Barom: 29.87". Hi: 77F Lo 58 F	Debris and trash in the mouth of the culvert. Lower water level. Foam on surface than last week, strong rotten smell. Clear water. Banks have algae	2:00a.m. Low:5,2 8:55 a.m.High:-0,4 4:36 p.m.Low: 4,3 9:05 p.m. High:3,2	No rain
05-22-00	Linda Mar	8:30	16.0	Sunny. 69F Winds from W 6 mph. Dew Point: 59F. Rel H: 70%. Visib: 7 miles. Barom: 29.97" Hi: 74F, Lo: 54F	Mostly sunny. 58F Wind from W 3 mph. Dew Point: 51F. relH: 77%. Visib: 9 miles. Barom: 29.87". Hi: 77F Lo 58 F	Water level low and clear, flowing fast on right side. A lot of riffles near sampling site. Creek a little bit narrower than last week	2:00a.m. Low:5,2 8:55 a.m.High:-0,4 4:36 p.m.Low: 4,3 9:05 p.m. High:3,2	No rain
05-22-00	Peralta	8:50	15.0	Sunny. 69F Winds from W 6 mph. Dew Point: 59F. Rel H: 70%. Visib: 7 miles. Barom: 29.97" Hi: 74F, Lo: 54F	Mostly sunny. 58F Wind from W 3 mph. Dew Point: 51F. relH: 77%. Visib: 9 miles. Barom: 29.87". Hi: 77F Lo 58 F	usual. Riffles after sampling site. Mosquitos. Water bugs-neuston. Water pretty clear. As always the bootom of this sampling site is sandy	2:00a.m. Low:5,2 8:55 a.m.High:-0,4 4:36 p.m.Low: 4,3 9:05 p.m. High:3,2	No rain
05-22-00	Outlet	9:25	19.0	Sunny. 69F Winds from W 6 mph. Dew Point: 59F. Rel H: 70%. Visib: 7 miles. Barom: 29.97" Hi: 74F, Lo: 54F	Mostly sunny. 58F Wind from W 3 mph. Dew Point: 51F. relH: 77%. Visib: 9 miles. Barom: 29.87". Hi: 77F Lo 58 F	Very low flow, clear water, sea weeds between sampling site and the ocean. Lots of debris	2:00a.m. Low:5,2 8:55 a.m.High:-0,4 4:36 p.m.Low: 4,3 9:05 p.m. High:3,2	No rain
05-22-00	Beach	9:35	19.0	Sunny. 69F Winds from W 6 mph. Dew Point: 59F. Rel H: 70%. Visib: 7 miles. Barom: 29.97" Hi: 74F, Lo: 54F	Mostly sunny. 58F Wind from W 3 mph. Dew Point: 51F. relH: 77%. Visib: 9 miles. Barom: 29.87". Hi: 77F Lo 58 F	Low tide. Some litter. Like 2 weeks ago, it is possible to see rocks covered by algae. Sea weeds	2:00a.m. Low:5,2 8:55 a.m.High:-0,4 4:36 p.m.Low: 4,3 9:05 p.m. High:3,2	No rain
05-22-00	Parking lot	9:45	20.0	Sunny. 69F Winds from W 6 mph. Dew Point: 59F. Rel H: 70%. Visib: 7 miles. Barom: 29.97" Hi: 74F, Lo: 54F	Mostly sunny. 58F Wind from W 3 mph. Dew Point: 51F. relH: 77%. Visib: 9 miles. Barom: 29.87". Hi: 77F Lo 58 F	Very low tide, foamy, cold water and windy	2:00a.m. Low:5,2 8:55 a.m.High:-0,4 4:36 p.m.Low: 4,3 9:05 p.m. High:3,2	No rain

Rainfall and tides information taken from the Pacifica Tribune

Appendix 5. General Physical Field Conditions

DATE	SITE	TIME (am)	AIR TEMP.	WEATHER CONDITIONS	WEATHER CONDITIONS	GENERAL FIELD CONDITIONS	TIDES (feet)	RAIN (Inches)
				Day Before Sampling	Sampling day			
07-17-00	Oddstad	7:20	16.0	Cloudy. 61F. Winds from SW 9 mph. Dew PointT: 54F Rel H: 74%. Visib: 10 miles. Barom: 30,04" HI: 66 F, Lo: 54 F	Cloudy. 57F. Winds from W 9 mph. Dew PointT: 54F Rel H: 90%. Visib: 10 miles. Barom: 30,07" and raising. HI: 66 F, Lo: 54 F	Soil very humid. Lots of Eucalyptus seeds and leaf litter. Creek narrow and shallow. Banana slugs all over	NA	No rain
07-17-00	N. Fork	7:50	15.6	Cloudy. 61F. Winds from SW 9 mph. Dew PointT: 54F Rel H: 74%. Visib: 10 miles. Barom: 30,04" HI: 66 F, Lo: 54 F	Cloudy. 57F. Winds from W 9 mph. Dew PointT: 54F Rel H: 90%. Visib: 10 miles. Barom: 30,07" and raising. HI: 66 F, Lo: 54 F	Algae on left side of sampling site. Garbage (bottles, clothes, plastics). Dripping noise inside the culvert. Foam. Brown sediment in the bottom. Clear water. A very strong sulphur smell	NA	No rain
07-17-00	Linda Mar	8:10	15.5	Cloudy. 61F. Winds from SW 9 mph. Dew PointT: 54F Rel H: 74%. Visib: 10 miles. Barom: 30,04" HI: 66 F, Lo: 54 F	Cloudy. 57F. Winds from W 9 mph. Dew PointT: 54F Rel H: 90%. Visib: 10 miles. Barom: 30,07" and raising. HI: 66 F, Lo: 54 F	The creek is straight in the sampling site. Clear water. Foam. Garbage in the creek.	NA	No rain
07-17-00	Peralta	8:30	16.5	Cloudy. 61F. Winds from SW 9 mph. Dew PointT: 54F Rel H: 74%. Visib: 10 miles. Barom: 30,04" HI: 66 F, Lo: 54 F	Cloudy. 57F. Winds from W 9 mph. Dew PointT: 54F Rel H: 90%. Visib: 10 miles. Barom: 30,07" and raising. HI: 66 F, Lo: 54 F	Very slow flow. Creek very shallow. Garbage like bottles. Clear water and leaves litter	NA	No rain
07-17-00	Outlet	9:20	16.5	Cloudy. 61F. Winds from SW 9 mph. Dew PointT: 54F Rel H: 74%. Visib: 10 miles. Barom: 30,04" HI: 66 F, Lo: 54 F	Cloudy. 57F. Winds from W 9 mph. Dew PointT: 54F Rel H: 90%. Visib: 10 miles. Barom: 30,07" and raising. HI: 66 F, Lo: 54 F	Clear water. The creek meanders. The shores are higher than last sampling period. Very low tide. Trunks and leaf litter.	NA	No rain
07-17-00	Beach	9:25	16.5	Cloudy. 61F. Winds from SW 9 mph. Dew PointT: 54F Rel H: 74%. Visib: 10 miles. Barom: 30,04" HI: 66 F, Lo: 54 F	Cloudy. 57F. Winds from W 9 mph. Dew PointT: 54F Rel H: 90%. Visib: 10 miles. Barom: 30,07" and raising. HI: 66 F, Lo: 54 F	Very low tide. Lots of algae in the beach	NA	No rain
07-17-00	Parking lot	9:40	16.0	Cloudy. 61F. Winds from SW 9 mph. Dew PointT: 54F Rel H: 74%. Visib: 10 miles. Barom: 30,04" HI: 66 F, Lo: 54 F	Cloudy. 57F. Winds from W 9 mph. Dew PointT: 54F Rel H: 90%. Visib: 10 miles. Barom: 30,07" and raising. HI: 66 F, Lo: 54 F	Low and calmed tide.	NA	No rain

Rainfall and tides information taken from the Pacifica Tribune

Appendix 5. General Physical Field Conditions

DATE	SITE	TIME (am)	AIR TEMP.	WEATHER CONDITIONS	WEATHER CONDITIONS	GENERAL FIELD CONDITIONS	TIDES (feet)	RAIN (Inches)
				Day Before Sampling	Sampling day			
07-24-00	Oddstad	7:20	15.0	Mostly sunny. 61F. Winds from NW 15 mph. Dew Point: 54F Rel H:84%. Visib: 10 miles. Barom: 30.07"and falling HI: 72 F, Lo: 54 F	Partly cloudy. 54F. Winds from W 10 mph. Dew Point: 52F Rel H:93%. Visib: 9 miles. Barom: 29.99"and falling HI: 71 F, Lo: 55 F	Shallow and clear creek. Eucalyptus smell. Leaf litter and Euc. Seeds in the creek. It was narrower than last time. Soil not as humid as last Monday. No banana slugs	High: 5:55 a.m. 3,9 Low: 11:29 a.m.1,6 High 6:25 p.m. 5.7	No rain
07-24-00	N. Fork	7:45	15.5	Mostly sunny. 61F. Winds from NW 15 mph. Dew Point: 54F Rel H:84%. Visib: 10 miles. Barom: 30.07"and falling HI: 72 F, Lo: 54 F	Partly cloudy. 54F. Winds from W 10 mph. Dew Point: 52F Rel H:93%. Visib: 9 miles. Barom: 29.99"and falling HI: 71 F, Lo: 55 F	Shallow and dripping side in the culvert. Lots of garbage. Algae in both shores. Sediment in the bottom	High: 5:55 a.m. 3,9 Low: 11:29 a.m.1,6 High 6:25 p.m. 5.7	No rain
07-24-00	Linda Mar	8:00	15.0	Mostly sunny. 61F. Winds from NW 15 mph. Dew Point: 54F Rel H:84%. Visib: 10 miles. Barom: 30.07"and falling HI: 72 F, Lo: 54 F	Partly cloudy. 54F. Winds from W 10 mph. Dew Point: 52F Rel H:93%. Visib: 9 miles. Barom: 29.99"and falling HI: 71 F, Lo: 55 F	Straight, narrow and shallow creek. Leaf litter in the creek. Down sampling site, very low flow and lots of garbage. Lots of riffles	High: 5:55 a.m. 3,9 Low: 11:29 a.m.1,6 High 6:25 p.m. 5.7	No rain
07-24-00	Peralta	8:20	15.0	Mostly sunny. 61F. Winds from NW 15 mph. Dew Point: 54F Rel H:84%. Visib: 10 miles. Barom: 30.07"and falling HI: 72 F, Lo: 54 F	Partly cloudy. 54F. Winds from W 10 mph. Dew Point: 52F Rel H:93%. Visib: 9 miles. Barom: 29.99"and falling HI: 71 F, Lo: 55 F	Narrow and clear. Very easy to see the bottom. Lots of cans and bottles. Riffle down sampling site. Bottom very sandy. I saw 1 trout. Lots of leaf litter in the bottom	High: 5:55 a.m. 3,9 Low: 11:29 a.m.1,6 High 6:25 p.m. 5.7	No rain
07-24-00	Outlet	8:57	14.5	Mostly sunny. 61F. Winds from NW 15 mph. Dew Point: 54F Rel H:84%. Visib: 10 miles. Barom: 30.07"and falling HI: 72 F, Lo: 54 F	Partly cloudy. 54F. Winds from W 10 mph. Dew Point: 52F Rel H:93%. Visib: 9 miles. Barom: 29.99"and falling HI: 71 F, Lo: 55 F	Narrow and very shallow. Sandy shores higher than last time. The creek meandered toward the end. Low tide and lots of birds	High: 5:55 a.m. 3,9 Low: 11:29 a.m.1,6 High 6:25 p.m. 5.7	No rain
07-24-00	Beach	9:10	15.0	Mostly sunny. 61F. Winds from NW 15 mph. Dew Point: 54F Rel H:84%. Visib: 10 miles. Barom: 30.07"and falling HI: 72 F, Lo: 54 F	Partly cloudy. 54F. Winds from W 10 mph. Dew Point: 52F Rel H:93%. Visib: 9 miles. Barom: 29.99"and falling HI: 71 F, Lo: 55 F	Low tide strong waves though. Lots of rocks exposed with algae. Windy	High: 5:55 a.m. 3,9 Low: 11:29 a.m.1,6 High 6:25 p.m. 5.7	No rain
07-24-00	Parking lot	9:15	15.0	Mostly sunny. 61F. Winds from NW 15 mph. Dew Point: 54F Rel H:84%. Visib: 10 miles. Barom: 30.07"and falling HI: 72 F, Lo: 54 F	Partly cloudy. 54F. Winds from W 10 mph. Dew Point: 52F Rel H:93%. Visib: 9 miles. Barom: 29.99"and falling HI: 71 F, Lo: 55 F	Low tide. Sea grass on the beach. Foggy and windy	High: 5:55 a.m. 3,9 Low: 11:29 a.m.1,6 High 6:25 p.m. 5.7	No rain

Rainfall and tides information taken from the Pacifica Tribune

Appendix 5. General Physical Field Conditions

DATE	SITE	TIME (am)	AIR TEMP. (C)	WEATHER CONDITIONS	WEATHER CONDITIONS	GENERAL FIELD CONDITIONS	TIDES (feet)	RAIN (Inches)
				Day Before Sampling	Sampling day			
07/31/00	Oddstad	7:15	15.0	Mostly cloudy. 57F. Winds from W 9 mph. Dew PointT: 54F Rel H: 90%. Visib: 10 miles. Barom: 29,92" HI: 72 F, Lo: 55 F	Drizzle. 54F. Winds from W 13 mph. Dew PointT: 53F Rel H: 96%. Visib: 6 miles. Barom: 29,90" and raising. HI: 73 F, Lo: 56 F	Lots of Eucalyptus' seeds and leaves. There was a bank in the sampling site. Some branches have felt into the creek. Clear water	Low: 6:20 a.m.-1,4 High: 1:29 p.m.5,4 Low: 6:15 p.m. 2,3	No rain
07/31/00	N. Fork	7:40	16.0	Mostly cloudy. 57F. Winds from W 9 mph. Dew PointT: 54F Rel H: 90%. Visib: 10 miles. Barom: 29,92" HI: 72 F, Lo: 55 F	Drizzle. 54F. Winds from W 13 mph. Dew PointT: 53F Rel H: 96%. Visib: 6 miles. Barom: 29,90" and raising. HI: 73 F, Lo: 56 F	Sampling site very dirty with plastics, bottles,etc. Lots of algae at the end of the culvert and right hand side. Though water is Clear is not possible to see the bottom. Smelled like urine	Low: 6:20 a.m.-1,4 High: 1:29 p.m.5,4 Low: 6:15 p.m. 2,3	No rain
07/31/00	Linda Mar	8:05	15.1	Mostly cloudy. 57F. Winds from W 9 mph. Dew PointT: 54F Rel H: 90%. Visib: 10 miles. Barom: 29,92" HI: 72 F, Lo: 55 F	Drizzle. 54F. Winds from W 13 mph. Dew PointT: 53F Rel H: 96%. Visib: 6 miles. Barom: 29,90" and raising. HI: 73 F, Lo: 56 F	Straight creek. Riffles in the sampling site and downstream. Clear water. Brwon sediment in the bottom. Downstream white foam	Low: 6:20 a.m.-1,4 High: 1:29 p.m.5,4 Low: 6:15 p.m. 2,3	No rain
07/31/00	Peralta	8:15	15.0	Mostly cloudy. 57F. Winds from W 9 mph. Dew PointT: 54F Rel H: 90%. Visib: 10 miles. Barom: 29,92" HI: 72 F, Lo: 55 F	Drizzle. 54F. Winds from W 13 mph. Dew PointT: 53F Rel H: 96%. Visib: 6 miles. Barom: 29,90" and raising. HI: 73 F, Lo: 56 F	Very low flow. High velocity toward the left shore. Several fish and branches in the creek No riffles downstream sampling site	Low: 6:20 a.m.-1,4 High: 1:29 p.m.5,4 Low: 6:15 p.m. 2,3	No rain
07/31/00	Outlet	9:15	19.0	Mostly cloudy. 57F. Winds from W 9 mph. Dew PointT: 54F Rel H: 90%. Visib: 10 miles. Barom: 29,92" HI: 72 F, Lo: 55 F	Drizzle. 54F. Winds from W 13 mph. Dew PointT: 53F Rel H: 96%. Visib: 6 miles. Barom: 29,90" and raising. HI: 73 F, Lo: 56 F	Creek meanderes toward left and then straight to the ocean. Some branches and garbage	Low: 6:20 a.m.-1,4 High: 1:29 p.m.5,4 Low: 6:15 p.m. 2,3	No rain
07/31/00	Beach	9:20	19.0	Mostly cloudy. 57F. Winds from W 9 mph. Dew PointT: 54F Rel H: 90%. Visib: 10 miles. Barom: 29,92" HI: 72 F, Lo: 55 F	Drizzle. 54F. Winds from W 13 mph. Dew PointT: 53F Rel H: 96%. Visib: 6 miles. Barom: 29,90" and raising. HI: 73 F, Lo: 56 F	High and strong tide compared with last week. Tide was mixing with creek. Some rocks covered with algae were exposed	Low: 6:20 a.m.-1,4 High: 1:29 p.m.5,4 Low: 6:15 p.m. 2,3	No rain
07/31/00	Parking lot	9:30	17.0	Mostly cloudy. 57F. Winds from W 9 mph. Dew PointT: 54F Rel H: 90%. Visib: 10 miles. Barom: 29,92" HI: 72 F, Lo: 55 F	Drizzle. 54F. Winds from W 13 mph. Dew PointT: 53F Rel H: 96%. Visib: 6 miles. Barom: 29,90" and raising. HI: 73 F, Lo: 56 F	Bad smell in the beach like methane. Higher and stronger tide tha las week. White foam in the beach	Low: 6:20 a.m.-1,4 High: 1:29 p.m.5,4 Low: 6:15 p.m. 2,3	No rain

Rainfall and tides information taken from the Pacifica Tribune

General Physical Field Conditions

DATE	SITE	TIME (am)	AIR TEMP. (C)	WEATHER CONDITIONS	WEATHER CONDITIONS	GENERAL FIELD CONDITIONS	TIDES (feet)	RAIN (Inches)
				Day Before Sampling	Sampling day			
7/8/2000	Oddstad	7:18	15.0	Mostly cloudy. 56F. Winds from SW 10 mph. Dew Point: 55F Rel H: 90%. Visib: 10 miles. Barom: 29.99" H: 68 F, Low: 55 F	Cloudy. 57F. Winds from SW 10 -20 mph. Dew Point: 54F Rel H: 90%. Visib: 9 miles. Barom: 29.93" H: 67 F, Low: 55 F	Drizzle. More flow. Some branches, leaves and Eucalyptus seeds in the creek. Field very wet. Below Samplig site there was a bank	Low: 12:30 a.m. 1,2 High: 6:55 a.m. 4,0 Low: 12:03 p.m. 2,2 High: 6:42 p.m. 5,8	No rain
7/8/2000	N. Fork	7:45	15.0	Mostly cloudy. 56F. Winds from SW 10 mph. Dew Point: 55F Rel H: 90%. Visib: 10 miles. Barom: 29.99" H: 68 F, Low: 55 F	Cloudy. 57F. Winds from SW 10 -20 mph. Dew Point: 54F Rel H: 90%. Visib: 9 miles. Barom: 29.93" H: 67 F, Low: 55 F	Lots of white foam. Dripping noise inside of the culvert. The cvolor of the water was yellow. Lots of algae and garbage	Low: 12:30 a.m. 1,2 High: 6:55 a.m. 4,0 Low: 12:03 p.m. 2,2 High: 6:42 p.m. 5,8	No rain
7/8/2000	Linda Mar	8:05	14.0	Mostly cloudy. 56F. Winds from SW 10 mph. Dew Point: 55F Rel H: 90%. Visib: 10 miles. Barom: 29.99" H: 68 F, Low: 55 F	Cloudy. 57F. Winds from SW 10 -20 mph. Dew Point: 54F Rel H: 90%. Visib: 9 miles. Barom: 29.93" H: 67 F, Low: 55 F	More flow. The foam was not present at this point just below it. The creek was prettu straigh in the sampling site. A riffle was present	Low: 12:30 a.m. 1,2 High: 6:55 a.m. 4,0 Low: 12:03 p.m. 2,2 High: 6:42 p.m. 5,8	No rain
7/8/2000	Peralta	8:20	15.0	Mostly cloudy. 56F. Winds from SW 10 mph. Dew Point: 55F Rel H: 90%. Visib: 10 miles. Barom: 29.99" H: 68 F, Low: 55 F	Cloudy. 57F. Winds from SW 10 -20 mph. Dew Point: 54F Rel H: 90%. Visib: 9 miles. Barom: 29.93" H: 67 F, Low: 55 F	Several fish. Brances and some garbage in the water. No foam and riffles. Bad smell in the area	Low: 12:30 a.m. 1,2 High: 6:55 a.m. 4,0 Low: 12:03 p.m. 2,2 High: 6:42 p.m. 5,8	No rain
7/8/2000	Outlet	9:05	13.5	from SW 10 mph. Dew Point: 55F Rel H: 90%. Visib: 10 miles. Barom: 29.99" H: 68 F, Low: 55 F	SW 10 -20 mph. Dew Point: 54F Rel H: 90%. Visib: 9 miles. Barom: 29.93" H: 67 F, Low: 55 F	The creek was straight and narrow at the sampling point. Clear water. Downstream was meadering	Low: 12:30 a.m. 1,2 High: 6:55 a.m. 4,0 Low: 12:03 p.m. 2,2 High: 6:42 p.m. 5,8	No rain
7/8/2000	Beach	9:10	13.0	Mostly cloudy. 56F. Winds from SW 10 mph. Dew Point: 55F Rel H: 90%. Visib: 10 miles. Barom: 29.99" H: 68 F, Low: 55 F	Cloudy. 57F. Winds from SW 10 -20 mph. Dew Point: 54F Rel H: 90%. Visib: 9 miles. Barom: 29.93" H: 67 F, Low: 55 F	Higher tide than last week. Very windy. Tyhe ocean was mixed with the freshwater	Low: 12:30 a.m. 1,2 High: 6:55 a.m. 4,0 Low: 12:03 p.m. 2,2 High: 6:42 p.m. 5,8	No rain
7/8/2000	Parking lot	9:20	14.0	Mostly cloudy. 56F. Winds from SW 10 mph. Dew Point: 55F Rel H: 90%. Visib: 10 miles. Barom: 29.99" H: 68 F, Low: 55 F	Cloudy. 57F. Winds from SW 10 -20 mph. Dew Point: 54F Rel H: 90%. Visib: 9 miles. Barom: 29.93" H: 67 F, Low: 55 F	Strong tide. Green foam in the beach. Pretty windy.	Low: 12:30 a.m. 1,2 High: 6:55 a.m. 4,0 Low: 12:03 p.m. 2,2 High: 6:42 p.m. 5,8	No rain

Rainfall and tides information taken from the Pacifica Tribune

Appendix 5. General Physical Field Conditions

DATE	SITE	TIME (am)	AIR TEMP. (C)	WEATHER CONDITIONS	WEATHER CONDITIONS	GENERAL FIELD CONDITIONS	TIDES (feet)	RAIN (Inches)
				Day Before Sampling	Sampling day			
08/14/00	Oddstad	7:20	14.5	Partly cloudy. 54F. Winds variable 5 mph. Dew PointT: 50F Rel H: 86%. Visib: 9 miles. Barom: 29,96" and falling HI: 72 F, Lo: 55 F	Partly cloudy. 56F. Wind from the W 10 mph. Dew PointT: 50F Rel H: 80%. Visib: 8 miles. Barom: 29,89" and falling HI: 75 F, Lo: 55 F	Low flow. Dry conditions. Leaf litter and Eucalyptus seeds. Bank below samplig site. Clear water	Low: 5:57 a.m.-0,1 High: 1:02 p.m.4,9 Low: 5:51 p.m.2,7 High:11:50 p.m.6,1	No rain
08/14/00	N. Fork	7:35	13.5	Partly cloudy. 54F. Winds variable 5 mph. Dew PointT: 50F Rel H: 86%. Visib: 9 miles. Barom: 29,96" and falling HI: 72 F, Lo: 55 F	Partly cloudy. 56F. Wind from the W 10 mph. Dew PointT: 50F Rel H: 80%. Visib: 8 miles. Barom: 29,89" and falling HI: 75 F, Lo: 55 F	No foam. Garbage such as bottles and plastics. Algae on the shore. Low flow compared to last week. Dripping noise inside of the culvert.	Low: 5:57 a.m.-0,1 High: 1:02 p.m.4,9 Low: 5:51 p.m.2,7 High:11:50 p.m.6,1	No rain
08/14/00	Linda Mar	7:55	14.0	Partly cloudy. 54F. Winds variable 5 mph. Dew PointT: 50F Rel H: 86%. Visib: 9 miles. Barom: 29,96" and falling HI: 72 F, Lo: 55 F	Partly cloudy. 56F. Wind from the W 10 mph. Dew PointT: 50F Rel H: 80%. Visib: 8 miles. Barom: 29,89" and falling HI: 75 F, Lo: 55 F	Low flow. Creek was straight in this area. Riffles in the sampling site. Clear water and some leaf litter	Low: 5:57 a.m.-0,1 High: 1:02 p.m.4,9 Low: 5:51 p.m.2,7 High:11:50 p.m.6,1	No rain
08/14/00	Peralta	8:10	15.5	Partly cloudy. 54F. Winds variable 5 mph. Dew PointT: 50F Rel H: 86%. Visib: 9 miles. Barom: 29,96" and falling HI: 72 F, Lo: 55 F	Partly cloudy. 56F. Wind from the W 10 mph. Dew PointT: 50F Rel H: 80%. Visib: 8 miles. Barom: 29,89" and falling HI: 75 F, Lo: 55 F	Very low flow. Leaf litter and garbage. The water barely moves	Low: 5:57 a.m.-0,1 High: 1:02 p.m.4,9 Low: 5:51 p.m.2,7 High:11:50 p.m.6,1	No rain
08/14/00	Outlet	8:45	18.0	Partly cloudy. 54F. Winds variable 5 mph. Dew PointT: 50F Rel H: 86%. Visib: 9 miles. Barom: 29,96" and falling HI: 72 F, Lo: 55 F	Partly cloudy. 56F. Wind from the W 10 mph. Dew PointT: 50F Rel H: 80%. Visib: 8 miles. Barom: 29,89" and falling HI: 75 F, Lo: 55 F	Very low flow. Creakk meanders a lot compared to last week. Clear water	Low: 5:57 a.m.-0,1 High: 1:02 p.m.4,9 Low: 5:51 p.m.2,7 High:11:50 p.m.6,1	No rain
08/14/00	Beach	8:50	18.0	Partly cloudy. 54F. Winds variable 5 mph. Dew PointT: 50F Rel H: 86%. Visib: 9 miles. Barom: 29,96" and falling HI: 72 F, Lo: 55 F	Partly cloudy. 56F. Wind from the W 10 mph. Dew PointT: 50F Rel H: 80%. Visib: 8 miles. Barom: 29,89" and falling HI: 75 F, Lo: 55 F	High tide though rock were exposed. Ocean water get mixed with creek water.	Low: 5:57 a.m.-0,1 High: 1:02 p.m.4,9 Low: 5:51 p.m.2,7 High:11:50 p.m.6,1	No rain
08/14/00	Parking lot	9:00	16.0	Partly cloudy. 54F. Winds variable 5 mph. Dew PointT: 50F Rel H: 86%. Visib: 9 miles. Barom: 29,96" and falling HI: 72 F, Lo: 55 F	Partly cloudy. 56F. Wind from the W 10 mph. Dew PointT: 50F Rel H: 80%. Visib: 8 miles. Barom: 29,89" and falling HI: 75 F, Lo: 55 F	High tide, stronger waves than last week	Low: 5:57 a.m.-0,1 High: 1:02 p.m.4,9 Low: 5:51 p.m.2,7 High:11:50 p.m.6,1	No rain

Rainfall and tides information taken from the Pacifica Tribune

Appendix 5. General Field Physical Conditions

DATE	SITE	TIME (am)	AIR TEMP. (C)	WEATHER CONDITIONS	WEATHER CONDITIONS	GENERAL FIELD CONDITIONS	TIDES (feet)	RAIN (Inches)
				Day Before Sampling	Sampling day			
10-16-00	Oddstad	7:20	12.0	Cloudy. 54F. Winds from S 5 mph. Dew Point: 50F Rel H: 86%. Visib: Unlimited. Barom: 30,05" and falling HI: 64 F, Lo: 52 F	Partly Cloudy. 50F. Winds from S 3 mph. Dew Point: 47F Rel H: 89%. Visib: Unlimited. Barom: 30,05" HI: 68 F, Lo: 50 F	Several Eucalyptus leaves and seeds. Clear water. The creek was narrow. Strong Eucalyptus smell. Riffle at the sampling site.	High: 2:39 a.m. 4,9 Low: 7:38 a.m. 2,2 High: 1:57 p.m. 6,1 Low: 8:30 p.m. -0,3	No rain
10-16-00	N. Fork	7:40	11.0	Cloudy. 54F. Winds from S 5 mph. Dew Point: 50F Rel H: 86%. Visib: Unlimited. Barom: 30,05" and falling HI: 64 F, Lo: 52 F	Partly Cloudy. 50F. Winds from S 3 mph. Dew Point: 47F Rel H: 89%. Visib: Unlimited. Barom: 30,05" HI: 68 F, Lo: 50 F	Low flow. Foam and algae toward the shores. Sediments on the creek bottom. Bad smell.	High: 2:39 a.m. 4,9 Low: 7:38 a.m. 2,2 High: 1:57 p.m. 6,1 Low: 8:30 p.m. -0,3	No rain
10-16-00	Linda Mar	8:00	11.0	Cloudy. 54F. Winds from S 5 mph. Dew Point: 50F Rel H: 86%. Visib: Unlimited. Barom: 30,05" and falling HI: 64 F, Lo: 52 F	Partly Cloudy. 50F. Winds from S 3 mph. Dew Point: 47F Rel H: 89%. Visib: Unlimited. Barom: 30,05" HI: 68 F, Lo: 50 F	The creek was narrow with a low flow. Riffle at the sampling site. Foam and some garbage like plastic bottles.	High: 2:39 a.m. 4,9 Low: 7:38 a.m. 2,2 High: 1:57 p.m. 6,1 Low: 8:30 p.m. -0,3	No rain
10-16-00	Peralta	8:20	12.5	Cloudy. 54F. Winds from S 5 mph. Dew Point: 50F Rel H: 86%. Visib: Unlimited. Barom: 30,05" and falling HI: 64 F, Lo: 52 F	Partly Cloudy. 50F. Winds from S 3 mph. Dew Point: 47F Rel H: 89%. Visib: Unlimited. Barom: 30,05" HI: 68 F, Lo: 50 F	Low flow not even riffles. Big ban where I sampled. Clamed water. One riffle up-stream	High: 2:39 a.m. 4,9 Low: 7:38 a.m. 2,2 High: 1:57 p.m. 6,1 Low: 8:30 p.m. -0,3	No rain
10-16-00	Outlet	9:00	15.0	Cloudy. 54F. Winds from S 5 mph. Dew Point: 50F Rel H: 86%. Visib: Unlimited. Barom: 30,05" and falling HI: 64 F, Lo: 52 F	Partly Cloudy. 50F. Winds from S 3 mph. Dew Point: 47F Rel H: 89%. Visib: Unlimited. Barom: 30,05" HI: 68 F, Lo: 50 F	The creek was narrow and meanders before reaches the ocean. Lots of garbage and birds taking a bad in the creek	High: 2:39 a.m. 4,9 Low: 7:38 a.m. 2,2 High: 1:57 p.m. 6,1 Low: 8:30 p.m. -0,3	No rain
10-16-00	Beach	9:10	15.0	Cloudy. 54F. Winds from S 5 mph. Dew Point: 50F Rel H: 86%. Visib: Unlimited. Barom: 30,05" and falling HI: 64 F, Lo: 52 F	Partly Cloudy. 50F. Winds from S 3 mph. Dew Point: 47F Rel H: 89%. Visib: Unlimited. Barom: 30,05" HI: 68 F, Lo: 50 F	Low tide. Lots of rocks were exposed with algae. Strong fish smell.	High: 2:39 a.m. 4,9 Low: 7:38 a.m. 2,2 High: 1:57 p.m. 6,1 Low: 8:30 p.m. -0,3	No rain
10-16-00	Parking lot	9:15	16.0	Cloudy. 54F. Winds from S 5 mph. Dew Point: 50F Rel H: 86%. Visib: Unlimited. Barom: 30,05" and falling HI: 64 F, Lo: 52 F	Partly Cloudy. 50F. Winds from S 3 mph. Dew Point: 47F Rel H: 89%. Visib: Unlimited. Barom: 30,05" HI: 68 F, Lo: 50 F	Low tide. Lots of crab carcasses on the beach	High: 2:39 a.m. 4,9 Low: 7:38 a.m. 2,2 High: 1:57 p.m. 6,1 Low: 8:30 p.m. -0,3	No rain

Rainfall events and tides information taken from the Pacifica Tribune

Appendix 5. General Field Physical Conditions

DATE	SITE	TIME (am)	AIR TEMP.	WEATHER CONDITIONS	WEATHER CONDITIONS	GENERAL FIELD CONDITIONS	TIDES (feet)	RAIN (Inches)
				Day Before Sampling	Sampling day			
10-23-00	Oddstad	7:50	14.0	Partly Cloudy. 61F. Winds from N 24 mph. Dew Point: 38F Rel H: 42%. Visib: Unlimited. Barom: 29.90" and falling HI: 75 F, Lo: 56 F	Fair. 58F. Winds from NE 12 mph. Dew Point: 41F Rel H: 53%. Visib: Unlimited. Barom: 29.90"and falling HI: 71 F, Lo: 53 F	Straight creek. Eucalyptus seeds and leaves in the creek. Clear water. Narrow creek.	High: 2:47 a.m. 0,1 Low: 9:49 a.m. 5,7 High: 3:26 p.m. 1,5 Low: 9:31 p.m. 5,4	No rain
10-23-00	N. Fork	8:15	14.0	Partly Cloudy. 61F. Winds from N 24 mph. Dew Point: 38F Rel H: 42%. Visib: Unlimited. Barom: 29.90" and falling HI: 75 F, Lo: 56 F	Fair. 58F. Winds from NE 12 mph. Dew Point: 41F Rel H: 53%. Visib: Unlimited. Barom: 29.90"and falling HI: 71 F, Lo: 53 F	Strong bad smell at the sampling site. Garbage. Dripping noise inside of the culvert. Foam downstream	High: 2:47 a.m. 0,1 Low: 9:49 a.m. 5,7 High: 3:26 p.m. 1,5 Low: 9:31 p.m. 5,4	No rain
10-23-00	Linda Mar	8:20	14.0	Partly Cloudy. 61F. Winds from N 24 mph. Dew Point: 38F Rel H: 42%. Visib: Unlimited. Barom: 29.90" and falling HI: 75 F, Lo: 56 F	Fair. 58F. Winds from NE 12 mph. Dew Point: 41F Rel H: 53%. Visib: Unlimited. Barom: 29.90"and falling HI: 71 F, Lo: 53 F	Narrow and low flow. Riffle at the sampling point. Some garbage. Foam downstream. Leaf litter.	High: 2:47 a.m. 0,1 Low: 9:49 a.m. 5,7 High: 3:26 p.m. 1,5 Low: 9:31 p.m. 5,4	No rain
10-23-00	Peralta	8:45	14.0	Partly Cloudy. 61F. Winds from N 24 mph. Dew Point: 38F Rel H: 42%. Visib: Unlimited. Barom: 29.90" and falling HI: 75 F, Lo: 56 F	Fair. 58F. Winds from NE 12 mph. Dew Point: 41F Rel H: 53%. Visib: Unlimited. Barom: 29.90"and falling HI: 71 F, Lo: 53 F	Water movement was barely noticed. Garbage. Riffle downstream. Bank at the sampling site.	High: 2:47 a.m. 0,1 Low: 9:49 a.m. 5,7 High: 3:26 p.m. 1,5 Low: 9:31 p.m. 5,4	No rain
10-23-00	Outlet	9:15	16.0	Partly Cloudy. 61F. Winds from N 24 mph. Dew Point: 38F Rel H: 42%. Visib: Unlimited. Barom: 29.90" and falling HI: 75 F, Lo: 56 F	Fair. 58F. Winds from NE 12 mph. Dew Point: 41F Rel H: 53%. Visib: Unlimited. Barom: 29.90"and falling HI: 71 F, Lo: 53 F	Garbgae at the samplignsite. Lots of birds, algae and sea grass. Creek ran straight to the ocean creating a "cliff".	High: 2:47 a.m. 0,1 Low: 9:49 a.m. 5,7 High: 3:26 p.m. 1,5 Low: 9:31 p.m. 5,4	No rain
10-23-00	Beach	9:20	16.0	Partly Cloudy. 61F. Winds from N 24 mph. Dew Point: 38F Rel H: 42%. Visib: Unlimited. Barom: 29.90" and falling HI: 75 F, Lo: 56 F	Fair. 58F. Winds from NE 12 mph. Dew Point: 41F Rel H: 53%. Visib: Unlimited. Barom: 29.90"and falling HI: 71 F, Lo: 53 F	High tide, strong waves moving the sand. Difficult to grab the samples.	High: 2:47 a.m. 0,1 Low: 9:49 a.m. 5,7 High: 3:26 p.m. 1,5 Low: 9:31 p.m. 5,4	No rain
10-23-00	Parking lot	9:30	16.3	Partly Cloudy. 61F. Winds from N 24 mph. Dew Point: 38F Rel H: 42%. Visib: Unlimited. Barom: 29.90" and falling HI: 75 F, Lo: 56 F	Fair. 58F. Winds from NE 12 mph. Dew Point: 41F Rel H: 53%. Visib: Unlimited. Barom: 29.90"and falling HI: 71 F, Lo: 53 F	High tide, strong waves moving the sand. Difficult to grab the samples.	High: 2:47 a.m. 0,1 Low: 9:49 a.m. 5,7 High: 3:26 p.m. 1,5 Low: 9:31 p.m. 5,4	No rain

Rainfall events and tides information taken from the Pacifica Tribune

Appendix 5. General Field Physical Conditions

DATE	SITE	TIME (am)	AIR TEMP. (C)	WEATHER CONDITIONS	WEATHER CONDITIONS	GENERAL FIELD CONDITIONS	TIDES (feet)	RAIN (Inches)
				Day Before Sampling	Sampling day			
10-30-00	Oddstad	7:25	15.0	Mostly Cloudy. 54F. Winds from W 3 mph. Dew Point: 50F Rel H: 86%. Visib: Unlimited. Barom: 29.99" and falling HI: 58 F, Lo: 54 F	Light rain. 53F. Winds from S 8 mph. Dew Point: 50F Rel H: 89%. Visib: Unlimited. Barom: 30.02" HI: 61 F, Lo: 49 F	Higher flow compared to last week. Strong Eucalyptus smell. Bank where I sampled. Leaf litter in the creek	High: 1:53 a.m. 4,7 Low: 6:40 a.m. 2,6 High: 12:43 p.m. 5,7 Low: 7:26 p.m. -0,2	0.4
10-30-00	N. Fork	7:45	13.0	Mostly Cloudy. 54F. Winds from W 3 mph. Dew Point: 50F Rel H: 86%. Visib: Unlimited. Barom: 29.99" and falling HI: 58 F, Lo: 54 F	Light rain. 53F. Winds from S 8 mph. Dew Point: 50F Rel H: 89%. Visib: Unlimited. Barom: 30.02" HI: 61 F, Lo: 49 F	Foam, strong dripping noise inside of the culvert. Strong sulphur smell. Some worms. Garbage like plastic bottles. Water with a yellow color.	High: 1:53 a.m. 4,7 Low: 6:40 a.m. 2,6 High: 12:43 p.m. 5,7 Low: 7:26 p.m. -0,2	0.4
10-30-00	Linda Mar	8:05	14.0	Mostly Cloudy. 54F. Winds from W 3 mph. Dew Point: 50F Rel H: 86%. Visib: Unlimited. Barom: 29.99" and falling HI: 58 F, Lo: 54 F	Light rain. 53F. Winds from S 8 mph. Dew Point: 50F Rel H: 89%. Visib: Unlimited. Barom: 30.02" HI: 61 F, Lo: 49 F	The creek was straight at the sampling point. Riffle. Foam, and some garbage. Water with a yellow color	High: 1:53 a.m. 4,7 Low: 6:40 a.m. 2,6 High: 12:43 p.m. 5,7 Low: 7:26 p.m. -0,2	0.4
10-30-00	Peratta	8:25	15.0	Mostly Cloudy. 54F. Winds from W 3 mph. Dew Point: 50F Rel H: 86%. Visib: Unlimited. Barom: 29.99" and falling HI: 58 F, Lo: 54 F	Light rain. 53F. Winds from S 8 mph. Dew Point: 50F Rel H: 89%. Visib: Unlimited. Barom: 30.02" HI: 61 F, Lo: 49 F	Creek at sampling site was wider than before. More flow. Vegetation tangled in one side of the creek.	High: 1:53 a.m. 4,7 Low: 6:40 a.m. 2,6 High: 12:43 p.m. 5,7 Low: 7:26 p.m. -0,2	0.4
10-30-00	Outlet	9:15	13.0	Mostly Cloudy. 54F. Winds from W 3 mph. Dew Point: 50F Rel H: 86%. Visib: Unlimited. Barom: 29.99" and falling HI: 58 F, Lo: 54 F	Light rain. 53F. Winds from S 8 mph. Dew Point: 50F Rel H: 89%. Visib: Unlimited. Barom: 30.02" HI: 61 F, Lo: 49 F	The creek was wider, and turbid. Water got mixed with ocean water. Lots of rocks, logs, and sea grass.	High: 1:53 a.m. 4,7 Low: 6:40 a.m. 2,6 High: 12:43 p.m. 5,7 Low: 7:26 p.m. -0,2	0.4
10-30-00	Beach	9:25	14.0	Mostly Cloudy. 54F. Winds from W 3 mph. Dew Point: 50F Rel H: 86%. Visib: Unlimited. Barom: 29.99" and falling HI: 58 F, Lo: 54 F	Light rain. 53F. Winds from S 8 mph. Dew Point: 50F Rel H: 89%. Visib: Unlimited. Barom: 30.02" HI: 61 F, Lo: 49 F	Very turbid, strong waves.	High: 1:53 a.m. 4,7 Low: 6:40 a.m. 2,6 High: 12:43 p.m. 5,7 Low: 7:26 p.m. -0,2	0.4
10-30-00	Parking lot	9:35	15.0	Mostly Cloudy. 54F. Winds from W 3 mph. Dew Point: 50F Rel H: 86%. Visib: Unlimited. Barom: 29.99" and falling HI: 58 F, Lo: 54 F	Light rain. 53F. Winds from S 8 mph. Dew Point: 50F Rel H: 89%. Visib: Unlimited. Barom: 30.02" HI: 61 F, Lo: 49 F	String and high waves, very turbid	High: 1:53 a.m. 4,7 Low: 6:40 a.m. 2,6 High: 12:43 p.m. 5,7 Low: 7:26 p.m. -0,2	0.4

Rainfall events and tides information taken from the Pacifica Tribune

Appendix 5. General Field Physical Conditions

DATE	SITE	TIME (am)	AIR TEMP. (C)	WEATHER CONDITIONS	WEATHER CONDITIONS	GENERAL FIELD CONDITIONS	TIDES (feet)	RAIN (Inches)
				Day Before Sampling	Sampling day			
11/13/00	Oddstad	7:20	7.0	Partly cloudy. 42F. Winds from SE 3 mph. Dew Point: 39F Rel H: 89%. Visib: Unlimited. Barom: 30,33" and falling HI: 57 F, Lo: 45 F	Partly cloudy. 40F. Winds from W 6 mph. Dew Point: 37F Rel H: 89%. Visib: Unlimited. Barom: 30,17" and raising HI: 54 F, Lo: 48 F	Very cold day. Lots of leaf litter. Very cold water. Eucalyotus seeds. Riffle at sampling site	High: 12:42a.m.4,9 Low: 5:31 a.m. 2,3 High:11:44 a.m.6,5 Low: 6:26 p.m.-1,1	No rain
11/13/00	N. Fork	7:40	6.0	Partly cloudy. 42F. Winds from SE 3 mph. Dew Point: 39F Rel H: 89%. Visib: Unlimited. Barom: 30,33" and falling HI: 57 F, Lo: 45 F	Partly cloudy. 40F. Winds from W 6 mph. Dew Point: 37F Rel H: 89%. Visib: Unlimited. Barom: 30,17" and raising HI: 54 F, Lo: 48 F	Dripping noise inside of the culvert. Bad smell. Yellow and turbid water, sediments and garbage were present	High: 12:42a.m.4,9 Low: 5:31 a.m. 2,3 High:11:44 a.m.6,5 Low: 6:26 p.m.-1,1	No rain
11/13/00	Linda Mar	7:50	10.5	Partly cloudy. 42F. Winds from SE 3 mph. Dew Point: 39F Rel H: 89%. Visib: Unlimited. Barom: 30,33" and falling HI: 57 F, Lo: 45 F	Partly cloudy. 40F. Winds from W 6 mph. Dew Point: 37F Rel H: 89%. Visib: Unlimited. Barom: 30,17" and raising HI: 54 F, Lo: 48 F	Riffles at sampling site. Leaf litter, sediments on the top of stream bed rocks. Low flow	High: 12:42a.m.4,9 Low: 5:31 a.m. 2,3 High:11:44 a.m.6,5 Low: 6:26 p.m.-1,1	No rain
11/13/00	Peralta	8:10	7.0	Partly cloudy. 42F. Winds from SE 3 mph. Dew Point: 39F Rel H: 89%. Visib: Unlimited. Barom: 30,33" and falling HI: 57 F, Lo: 45 F	Partly cloudy. 40F. Winds from W 6 mph. Dew Point: 37F Rel H: 89%. Visib: Unlimited. Barom: 30,17" and raising HI: 54 F, Lo: 48 F	Very low flow. Riffle downstream sampling site. Upstream oily layer with leaf litter and garbage. Fish were observed	High: 12:42a.m.4,9 Low: 5:31 a.m. 2,3 High:11:44 a.m.6,5 Low: 6:26 p.m.-1,1	No rain
11/13/00	Outlet	8:55	10.0	Partly cloudy. 42F. Winds from SE 3 mph. Dew Point: 39F Rel H: 89%. Visib: Unlimited. Barom: 30,33" and falling HI: 57 F, Lo: 45 F	Partly cloudy. 40F. Winds from W 6 mph. Dew Point: 37F Rel H: 89%. Visib: Unlimited. Barom: 30,17" and raising HI: 54 F, Lo: 48 F	Low flow, narrow creek. The creek meanders before it reaches the ocean. Garbage, plascitcs, algae and sea weeds were present	High: 12:42a.m.4,9 Low: 5:31 a.m. 2,3 High:11:44 a.m.6,5 Low: 6:26 p.m.-1,1	No rain
11/13/00	Beach	9:00	11.0	Partly cloudy. 42F. Winds from SE 3 mph. Dew Point: 39F Rel H: 89%. Visib: Unlimited. Barom: 30,33" and falling HI: 57 F, Lo: 45 F	Partly cloudy. 40F. Winds from W 6 mph. Dew Point: 37F Rel H: 89%. Visib: Unlimited. Barom: 30,17" and raising HI: 54 F, Lo: 48 F	High tide. Creek water and ocean water were mixing. No strong tides	High: 12:42a.m.4,9 Low: 5:31 a.m. 2,3 High:11:44 a.m.6,5 Low: 6:26 p.m.-1,1	No rain
11/13/00	Parking lot	9:10	11.0	Partly cloudy. 42F. Winds from SE 3 mph. Dew Point: 39F Rel H: 89%. Visib: Unlimited. Barom: 30,33" and falling HI: 57 F, Lo: 45 F	Partly cloudy. 40F. Winds from W 6 mph. Dew Point: 37F Rel H: 89%. Visib: Unlimited. Barom: 30,17" and raising HI: 54 F, Lo: 48 F	High tides lost of birds. Calmed water, no strong tides	High: 12:42a.m.4,9 Low: 5:31 a.m. 2,3 High:11:44 a.m.6,5 Low: 6:26 p.m.-1,1	No rain

Rainfall events and tides information taken from the Pacifica Tribune

Appendix 6. Physical and Chemical Parameters Analyzed in the Field

DATE	SITE	DISSOLVED OXYGEN (mg/l)	AIR TEMPERATURE (C)	pH	WATER TEMPERATURE (C)	CONDUCTIVITY (uS/cm)
01-24-00	Oddstad	N/M	N/M	N/M	N/M	N/M
01-24-00	North Fork	N/M	N/M	N/M	N/M	N/M
01-24-00	Linda Mar	N/M	N/M	N/M	N/M	N/M
01-24-00	Peralta	N/M	N/M	N/M	N/M	N/M
01-24-00	Outlet	N/M	N/M	N/M	N/M	N/M
01-24-00	Beach	N/M	N/M	N/M	N/M	N/M
01-24-00	Parking lot	N/M	N/M	N/M	N/M	N/M
01-31-00	Oddstad	N/M	11.0	7.41	10.7	272
01-31-00	North Fork	N/M	11.0	N/M	13.1	462
01-31-00	Linda Mar	N/M	11.0	N/M	12.1	405
01-31-00	Peralta	N/M	11.5	N/M	11.5	410
01-31-00	Outlet	N/M	12.0	N/M	11.8	526
01-31-00	Beach	N/M	12.0	N/M	13.8	20600
01-31-00	Parking lot	N/M	12.0	N/M	13.3	23900
02-07-00	Oddstad	11	16.0	N/M	12.0	175
02-07-00	North Fork	10.2	15.0	N/M	12.0	612
02-07-00	Linda Mar	10.4	15.0	N/M	12.3	391
02-07-00	Peralta	10.4	16.0	N/M	12.9	428
02-07-00	Outlet	10.15	16.0	N/M	12.7	423
02-07-00	Beach	N/M	16.0	N/M	12.7	28200
02-07-00	Parking lot	N/M	16.0	N/M	12.8	27700
02-14-00	Oddstad	10.8	14.0	7.39	12.1	149
02-14-00	North Fork	10.6	14.0	7.92	12.6	268
02-14-00	Linda Mar	11	14.0	7.66	12.2	193
02-14-00	Peralta	10.8	14.0	7.49	12.3	221
02-14-00	Outlet	10.4	15.0	7.75	13.2	226
02-14-00	Beach	N/M	15.0	7.92	12.9	25300
02-14-00	Parking lot	N/M	15.0	8.27	13.2	28600
02-22-00	Oddstad	10.65	12.0	7.24	11.2	273
02-22-00	North Fork	10.5	13.0	7.66	13	566
02-22-00	Linda Mar	10.8	12.5	7.71	12.3	378
02-22-00	Peralta	10.8	13.0	7.88	12.1	414
02-22-00	Outlet	10.4	13.5	7.74	12.2	397
02-22-00	Beach	N/M	13.5	7.88	12.5	14700
02-22-00	Parking lot	N/M	13.5	7.85	12.9	30500
02-28-00	Oddstad	10.8	11.0	7.77	11.5	200
02-28-00	North Fork	10	12.0	7.73	12.2	402
02-28-00	Linda Mar	10.6	12.0	7.53	11.2	259
02-28-00	Peralta	10.6	14.0	7.63	11.4	285
02-28-00	Outlet	10.1	13.5	7.57	11.7	295
02-28-00	Beach	N/M	13.5	8.08	12.2	25400
02-28-00	Parking lot	N/M	13.5	8.11	12.4	27400

NM: No Measurement

Appendix 6. Physical and Chemical Parameters Analyzed in the Field

DATE	SITE	DISSOLVED OXYGEN (mg/l)	AIR TEMPERATURE (C)	pH	WATER TEMPERATURE (C)	CONDUCTIVITY (uS/cm)
04-24-00	Oddstad	10.4	10.5	7.89	10.8	223
04-24-00	N. Fork	9.8	15.0	8.05	13.7	586
04-24-00	Linda Mar	10	14.5	8.20	12.5	356
04-24-00	Peralta	10	16.0	8.35	13.5	357
04-24-00	Outlet	9.8	15.0	8.30	13.8	360
04-24-00	Beach	N/M	14.5	8.25	13.4	23000
04-24-00	Parking lot	N/M	14.5	8.23	13.6	24100
05-01-00	Oddstad	10.2	13.5	7.61	11.3	272
05-01-00	N. Fork	9.4	14.5	8.03	14.4	669
05-01-00	Linda Mar	10.2	15.0	8.13	12.4	462
05-01-00	Peralta	10.4	17.0	8.29	13.0	448
05-01-00	Outlet	10.6	18.0	8.31	14.4	442
05-01-00	Beach	N/M	16.0	7.96	13.4	27100
05-01-00	Parking lot	N/M	15.0	7.97	13.4	28100
05-09-00	Oddstad	10.6	15.0	8.04	12.8	204
05-09-00	N. Fork	9.4	15.2	8.03	15.1	518
05-09-00	Linda Mar	10.1	15.0	8.09	13.2	300
05-09-00	Peralta	10.8	15.0	8.25	14.4	306
05-09-00	Outlet	10.1	18.0	8.27	14.0	308
05-09-00	Beach	N/M	18.0	8.25	14.2	21400
05-09-00	Parking lot	N/M	18.0	8.29	14.3	22300
05-15-00	Oddstad	10.2	14.5	7.72	12.7	422
05-15-00	N. Fork	9.4	17.0	7.99	15	673
05-15-00	Linda Mar	10	17.0	8.18	13.3	415
05-15-00	Peralta	10	16.0	8.27	13.5	360
05-15-00	Outlet	9.4	21.0	8.24	14.8	348
05-15-00	Beach	N/M	18.0	8.11	13.5	28300
05-15-00	Parking lot	N/M	18.0	8.13	11.8	30800
05-22-00	Oddstad	10.1	15.0	8.09	12.8	266
05-22-00	N. Fork	9.2	17.0	8.00	15.8	666
05-22-00	Linda Mar	9.6	16.0	8.18	14.4	442
05-22-00	Peralta	10	15.0	8.38	13.8	422
05-22-00	Outlet	10.1	19.0	8.35	15.4	409
05-22-00	Beach	N/M	19.0	8.17	14.9	30600
05-22-00	Parking lot	N/M	20.0	8.16	14.3	31800

Appendix 6. Physical and Chemical Parameters Analyzed in the Field

DATE	SITE	DISSOLVED OXYGEN (mg/l)	AIR TEMPERATURE (C)	pH	WATER TEMPERATURE (C)	CONDUCTIVITY (uS/cm)
07-17-00	Oddstad	10.2	16.0	7.90	14.2	222
07-17-00	N. Fork	9.8	15.6	7.96	15.9	665
07-17-00	Linda Mar	10.2	15.5	8.09	14.5	311
07-17-00	Peralta	10.2	16.5	8.30	14.5	374
07-17-00	Outlet	9.6	16.5	8.34	14.7	378
07-17-00	Beach	N/M	16.5	8.47	15.3	28900
07-17-00	Parking lot	N/M	16.0	8.47	15.5	29300
07-24-00	Oddstad	10.2	15.0	8.13	12.1	210
07-24-00	N. Fork	9.9	15.5	8.16	15.3	558
07-24-00	Linda Mar	10.3	15.0	8.27	13.1	304
07-24-00	Peralta	10.4	15.0	8.41	13.2	301
07-24-00	Outlet	10.1	14.5	8.35	14.6	306
07-24-00	Beach	N/M	15.0	8.18	14.7	23700
07-24-00	Parking lot	N/M	15.0	8.19	15.2	24300
07-31-00	Oddstad	10.2	15.0	7.97	13.6	302
07-31-00	N. Fork	9.8	16.0	8.02	16.1	770
07-31-00	Linda Mar	10.0	15.1	8.24	14.4	404
07-31-00	Peralta	10.1	15.0	8.36	14.5	418
07-31-00	Outlet	10.0	19.0	8.27	16.0	473
07-31-00	Beach	N/M	19.0	8.14	14.9	30600
07-31-00	Parking lot	N/M	17.0	8.14	15.1	31100
08-07-00	Oddstad	9.6	15.0	8.00	13.8	226
08-07-00	N. Fork	8.9	15.0	7.74	16.3	635
08-07-00	Linda Mar	9.3	14.0	8.06	14.2	371
08-07-00	Peralta	9.4	15.0	8.31	14.2	407
08-07-00	Outlet	9.0	13.5	8.25	14.4	382
08-07-00	Beach	N/M	13.0	8.24	14.4	17900
08-07-00	Parking lot	N/M	14.0	8.34	14.2	30900
08-14-00	Oddstad	10.6	14.5	7.88	12.2	234
08-14-00	N. Fork	10	13.5	8.26	15.2	771
08-14-00	Linda Mar	10	14.0	8.39	13	412
08-14-00	Peralta	10.1	15.5	8.50	13.1	391
08-14-00	Outlet	9.6	18.0	8.44	14.4	458
08-14-00	Beach	N/M	18.0	8.44	14.4	28800
08-14-00	Parking lot	N/M	16.0	8.44	13.9	29800

Appendix 6. Physical and Chemical Parameters Analyzed in the Field

DATE	SITE	DISSOLVED OXYGEN (mg/l)	AIR TEMPERATURE (C)	pH	WATER TEMPERATURE (C)	CONDUCTIVITY (uS/cm)
10-16-00	Oddstad	10.1	12.0	8.03	11.3	178
10-16-00	N. Fork	9.4	11.0	8.07	11.7	467
10-16-00	Linda Mar	10	11.0	8.16	11.7	221
10-16-00	Peralta	10.1	12.5	8.28	11.3	232
10-16-00	Outlet	9.4	15.0	8.20	13.0	230
10-16-00	Beach	NS	15.0	8.18	14.5	17500
10-16-00	Parking lot	NS	16.0	7.96	13.7	18500
10-23-00	Oddstad	10.4	14.0	7.87	10.9	252
10-23-00	N. Fork	9.5	14.0	8.00	14.4	815
10-23-00	Linda Mar	10	14.0	8.14	11.7	404
10-23-00	Peralta	10.2	14.0	8.22	11.0	441
10-23-00	Outlet	9.6	16.0	8.14	12.1	422
10-23-00	Beach	NS	16.0	8.04	13.0	32300
10-23-00	Parking lot	NS	16.3	8.01	13.7	32900
10-30-00	Oddstad	10.2	15.0	7.93	12.2	254
10-30-00	N. Fork	9.8	13.0	7.78	14.7	553
10-30-00	Linda Mar	10.0	14.0	7.97	13.4	364
10-30-00	Peralta	9.8	15.0	8.13	13.2	325
10-30-00	Outlet	9.4	13.0	8.02	13.3	421
10-30-00	Beach	NS	14.0	8.13	13.3	23500
10-30-00	Parking lot	NS	15.0	8.12	13.5	29700
11-06-00	Oddstad	10.0	14.0	7.98	12.2	251
11-06-00	N. Fork	9.4	14.0	8.02	15.3	758
11-06-00	Linda Mar	10.0	13.0	8.15	12.9	410
11-06-00	Peralta	9.9	13.0	8.21	12.2	422
11-06-00	Outlet	9.8	14.0	8.23	12.7	427
11-06-00	Beach	NS	14.0	8.16	13.3	28700
11-06-00	Parking lot	NS	13.0	8.22	13.7	31900
11-13-00	Oddstad	11.2	7.0	7.93	8.7	231
11-13-00	N. Fork	9.9	6.0	8.05	12.8	720
11-13-00	Linda Mar	10.7	10.5	8.12	8.8	351
11-13-00	Peralta	11	7.0	8.20	8.1	371
11-13-00	Outlet	11	10.0	8.17	8.9	383
11-13-00	Beach	NS	11.0	7.98	11.2	28200
11-13-00	Parking lot	NS	11.0	7.89	11.6	29900

Appendix 7. Nitrates, Nitrites, Nitrogen Ammonia,
Phosphorus and Total Suspended Solids

DATE	SITE	PARAMETER mg/L	RESULTS mg/L
04/24/00	Oddstad	Ammonia as N	ND
		Nitrate as NO3	5.72
		Nitrite as NO2	ND
		Phosphorus	0.0300
		Total Suspended Solids	ND
04/24/00	North Fork	Ammonia as N	0.302
		Nitrate as NO3	6.71
		Nitrite as NO2	ND
		Phosphorus	0.0250
		Total Suspended Solids	ND
1/5/2000	Oddstad	Ammonia as N	ND
		Nitrate as NO3	6.70
		Nitrite as NO2	ND
		Phosphorus	ND
		Total Suspended Solids	162
1/5/2000	North Fork	Ammonia as N	0.156
		Nitrate as NO3	7.62
		Nitrite as NO2	ND
		Phosphorus	0.0190
		Total Suspended Solids	ND
9/5/2000	Oddstad	Ammonia as N	ND
		Nitrate as NO3	6.78
		Nitrite as NO2	ND
		Phosphorus	ND
		Total Suspended Solids	ND

ND : No Determined

Appendix 7. Nitrates, Nitrites, Nitrogen Ammonia,
Phosphorus and Total Suspended Solids

DATE	SITE	PARAMETER mg/L	RESULTS mg/L
9/5/2000	North Fork	Ammonia as N	0.276
		Nitrate as NO3	7.79
		Nitrite as NO2	ND
		Phosphorus	0.0500
		Total Suspended Solids	ND
05/15/00	Oddstad	Ammonia as N	ND
		Nitrate as NO3	6.37
		Nitrite as NO2	ND
		Phosphorus	0.0300
		Total Suspended Solids	ND
05/15/00	North Fork	Ammonia as N	0.189
		Nitrate as NO3	7.45
		Nitrite as NO2	ND
		Phosphorus	0.0250
		Total Suspended Solids	ND
05/22/00	Oddstad	Ammonia as N	ND
		Nitrate as NO3	6.50
		Nitrite as NO2	ND
		Phosphorus	0.0270
		Total Suspended Solids	ND
05/22/00	North Fork	Ammonia as N	0.292
		Nitrate as NO3	7.40
		Nitrite as NO2	ND
		Phosphorus	0.0270
		Total Suspended Solids	ND

Appendix 8. Turbidity Analyses

DATE	SITE	READING 1 NTU	READING2 NTU	AVERAGE READING	RANGE
07/02/00	Oddstad	8.8	8.7	8.75	200
07/02/00	North Fork	14	15	14.50	200
07/02/00	Linda Mar	12	12	12.00	200
07/02/00	Peralta	16	14	15.00	200
07/02/00	Outlet	7.7	6.5	7.10	200
07/02/00	Beach	7.7	6.8	7.25	200
07/02/00	Parking lot	10	12	11.00	200
02/14/00	Oddstad	370	398	384.00	200
02/14/00	North Fork	114	114	114.00	200
02/14/00	Linda Mar	296	298	297.00	200
02/14/00	Peralta	360	350	355.00	200
02/14/00	Outlet	352	360	356.00	200
02/14/00	Beach	304	316	310.00	200
02/14/00	Parking lot	24	21	300.00	200
02/22/00	Oddstad	27	24	25.50	200
02/22/00	North Fork	27	27	27.00	200
02/22/00	Linda Mar	21	25	23.00	200
02/22/00	Peralta	26	29	27.50	200
02/22/00	Outlet	22	23	22.50	200
02/22/00	Beach	25	27	26.00	200
02/22/00	Parking lot	20	15	17.50	200
02/28/00	Oddstad	21	23	22.00	200
02/28/00	North Fork	15	14	14.50	200
02/28/00	Linda Mar	22	22	22.00	200
02/28/00	Peralta	33	35	34.00	200
02/28/00	Outlet	33	33	33.00	200
02/28/00	Beach	27	26	26.50	200
02/28/00	Parking lot	7.8	8	17.50	200

Appendix 8. Turbidity Analyses

DATE	SITE	READING 1 NTU	READING2 NTU	AVERAGE READING	RANGE
04/24/00	Oddstad	2.2	2.5	2.35	20
04/24/00	North Fork	2.5	2.9	2.70	20
04/24/00	Linda Mar	2.3	2.4	2.35	20
04/24/00	Peralta	2.4	2.6	2.50	20
04/24/00	Outlet	2.3	2.5	2.40	20
04/24/00	Beach	4.7	4.9	4.80	20
04/24/00	Parking lot	4.8	4.5	4.65	20
1/5/2000	Oddstad	1.2	1.3	1.25	20
1/5/2000	North Fork	3.0	3.2	3.10	20
1/5/2000	Linda Mar	2.9	3.0	2.95	20
1/5/2000	Peralta	2.5	2.4	2.45	20
1/5/2000	Outlet	1.9	2.0	1.95	20
1/5/2000	Beach	4.0	4.1	4.05	20
1/5/2000	Parking lot	8.7	9.1	8.90	20
9/5/2000	Oddstad	2.9	3.2	3.05	20
9/5/2000	North Fork	2.8	2.7	2.75	20
9/5/2000	Linda Mar	2.4	2.5	2.45	20
9/5/2000	Peralta	2.2	2.2	2.20	20
9/5/2000	Outlet	2.2	2.4	2.30	20
9/5/2000	Beach	2.1	2.0	2.05	20
9/5/2000	Parking lot	1.9	2.0	1.95	20
05/15/00	Oddstad	1.5	1.4	1.45	20
05/15/00	North Fork	2.6	2.7	2.65	20
05/15/00	Linda Mar	1.6	1.8	1.70	20
05/15/00	Peralta	3.4	3.3	3.35	20
05/15/00	Outlet	3.1	3.2	3.15	20
05/15/00	Beach	5.7	6	5.85	20
05/15/00	Parking lot	6.6	6.4	6.50	20
05/22/00	Oddstad	1.1	1.1	1.10	20
05/22/00	North Fork	2.6	2.8	2.70	20
05/22/00	Linda Mar	1.7	1.4	1.55	20
05/22/00	Peralta	1.6	1.4	1.50	20
05/22/00	Outlet	1.9	1.7	1.80	20
05/22/00	Beach	2.6	2.7	2.65	20
05/22/00	Parking lot	2.5	2.5	2.50	20

Appendix 8. Turbidity Analyses

DATE	SITE	READING 1 NTU	READING2 NTU	AVERAGE READING	RANGE
07-17-00	Oddstad	1.1	1.2	1.15	20
07-17-00	North Fork	3.5	3.6	3.55	20
07-17-00	Linda Mar	1.8	1.9	1.85	20
07-17-00	Peralta	1.5	1.5	1.50	20
07-17-00	Outlet	1.1	1.3	1.20	20
07-17-00	Beach	1.6	1.6	1.60	20
07-17-00	Parking lot	1.7	1.5	1.60	20
07-24-00	Oddstad	0.7	1	0.85	20
07-24-00	North Fork	4.7	4.6	4.65	20
07-24-00	Linda Mar	1.7	1.6	1.65	20
07-24-00	Peralta	1.0	1.1	1.05	20
07-24-00	Outlet	1.2	1.3	1.25	20
07-24-00	Beach	1.5	1.7	1.60	20
07-24-00	Parking lot	1.7	1.7	1.70	20
07-31-00	Oddstad	0.6	0.7	0.65	20
07-31-00	North Fork	4.1	4.2	4.15	20
07-31-00	Linda Mar	1.6	1.7	1.65	20
07-31-00	Peralta	1.3	1	1.15	20
07-31-00	Outlet	1.3	1.2	1.25	20
07-31-00	Beach	2.1	1.9	2.00	20
07-31-00	Parking lot	1.6	1.9	1.75	20
08-07-00	Oddstad	1.3	1.4	1.35	20
08-07-00	North Fork	8.8	8.6	8.70	20
08-07-00	Linda Mar	3.8	3.7	3.75	20
08-07-00	Peralta	1.6	1.5	1.55	20
08-07-00	Outlet	2.1	1.9	2.00	20
08-07-00	Beach	2.7	2.6	2.65	20
08-07-00	Parking lot	2.2	2.3	2.25	20
08-14-00	Oddstad	0.5	0.6	0.55	20
08-14-00	North Fork	4.1	4.3	4.20	20
08-14-00	Linda Mar	1.7	1.5	1.60	20
08-14-00	Peralta	1.0	1.2	1.10	20
08-14-00	Outlet	1.4	1.5	1.45	20
08-14-00	Beach	4.0	4.1	4.05	20
08-14-00	Parking lot	3.3	3.5	3.40	20

Appendix 8. Turbidity Analyses

DATE	SITE	READING 1 NTU	READING2 NTU	AVERAGE READING	RANGE
10-16-00	Oddstad	0.6	0.5	0.55	20
10-16-00	North Fork	4.5	4.6	4.55	20
10-16-00	Linda Mar	1.2	1.3	1.25	20
10-16-00	Peralta	1.5	1.3	1.40	20
10-16-00	Outlet	2.6	2.4	2.50	20
10-16-00	Beach	3.2	3.3	3.25	20
10-16-00	Parking lot	3.1	3.3	3.20	20
10-23-00	Oddstad	0.5	0.7	0.60	20
10-23-00	North Fork	4.4	4.2	4.30	20
10-23-00	Linda Mar	1.6	1.4	1.50	20
10-23-00	Peralta	1.7	1.6	1.65	20
10-23-00	Outlet	2.0	2.1	2.05	20
10-23-00	Beach	6.5	6.6	6.55	20
10-23-00	Parking lot	4.6	4.4	4.50	20
10-30-00	Oddstad	0.6	0.8	0.70	20
10-30-00	North Fork	7.2	7.4	7.30	20
10-30-00	Linda Mar	4.2	4.3	4.25	20
10-30-00	Peralta	4.1	4.0	4.05	20
10-30-00	Outlet	7.8	7.9	7.85	20
10-30-00	Beach	8.4	8.5	8.45	20
10-30-00	Parking lot	9.1	9.1	9.10	20
11-06-00	Oddstad	0.8	0.6	0.70	20
11-06-00	North Fork	4.1	4	4.05	20
11-06-00	Linda Mar	1.4	1.2	1.30	20
11-06-00	Peralta	1.0	1.1	1.05	20
11-06-00	Outlet	1.0	0.9	0.95	20
11-06-00	Beach	3.8	3.6	3.70	20
11-06-00	Parking lot	4.1	4	4.05	20
11-13-00	Oddstad	0.5	0.8	0.65	20
11-13-00	North Fork	3.9	4	3.95	20
11-13-00	Linda Mar	1.3	1.1	1.20	20
11-13-00	Peralta	0.5	0.4	0.45	20
11-13-00	Outlet	0.8	0.7	0.75	20
11-13-00	Beach	3.3	3.3	3.30	20
11-13-00	Parking lot	3.2	2.9	3.05	20

Appendix 9. Discharge at Peralta Bridge

DATE	WIDTH feet	DEPTH feet	VELOCITY feet/sec	DISCHARGE cfs	DISCHARGE cms
7/2/2000	1.50	0.4	0.07	0.04200	
	1.00	0.350	0.49	0.17150	
	1.00	0.210	0.53	0.11130	
	1.00	0.200	0.73	0.14600	
	1.00	0.360	0.80	0.28800	
	1.00	0.530	0.79	0.41870	
	1.00	0.780	0.78	0.60840	
	1.00	0.900	0.63	0.56700	
	1.00	0.920	0.69	0.63480	
	1.00	0.920	0.67	0.61640	
	1.00	0.900	0.64	0.57600	
	1.00	0.900	0.64	0.57600	
	1.00	0.850	0.70	0.59500	
	1.00	0.850	0.39	0.33150	
	1.00	0.550	0.12	0.06600	
DISCHARGE cfs				5.7	0.163
HEIGHT FROM BRIDGE(feet)				18.2	

DATE	TIME Sec.	BRIDGE LENGTH	BRIDGE WIDTH	BRIDGE AREA	DISCHARGE cms
02-14-00	10.5	47'65"	18'6"		
	7.4				
	8.9				
	6.9				
	6.8				
	6.8				
	6.8				
	7.0				
	9.5				
	10.2				
Average time	80.8				
MEAN SURFACE VELOCITY	8.1				
MEAN VELOCITY ft/sec	7.35	5.88			
DISCHARGE cfs	38.069		223.84572	193	5.467
HEIGHT FROM BRIDGE(feet)				15' at 11:30 a.m.	16' at 3 p.m.

Appendix 9. Discharge at Peralta Bridge

DATE	WIDTH feet	DEPTH feet	VELOCITY feet/sec	DISCHARGE cfs	DISCHARGE cms
02-22-00	1.50	0.75	0.49	0.55125	
	1.00	0.42	0.90	0.37800	
	1.00	0.35	1.24	0.43400	
	1.00	0.32	1.32	0.42240	
	1.00	0.37	1.43	0.52910	
	1.00	0.42	1.54	0.64680	
	1.00	0.50	1.64	0.82000	
	1.00	0.52	1.68	0.87360	
	1.00	0.52	1.70	0.88400	
	1.00	0.53	1.74	0.92220	
	1.00	0.54	1.79	0.96660	
	1.00	0.63	1.66	1.04580	
	1.00	0.77	1.54	1.18580	
	1.00	0.84	1.37	1.15080	
	1.00	0.87	0.93	0.80910	
	1.00	0.60	0.55	0.33000	
DISCHARGE cfs				11.9	0.339
HEIGHT FROM BRIDGE(feet)				18.0	

DATE	WIDTH feet	DEPTH feet	VELOCITY feet/sec	DISCHARGE cfs	DISCHARGE cms
02-28-00	1.50	1.15	0.14	0.24150	
	1.00	1.25	0.45	0.56250	
	1.00	1.1	0.87	0.95700	
	1.00	1.1	1.43	1.57300	
	1.00	1.17	1.61	1.88370	
	1.00	1.2	2.33	2.79600	
	1.00	1.2	2.64	3.16800	
	1.00	1.3	2.41	3.13300	
	1.00	1.3	2.62	3.40600	
	1.00	1.35	2.72	3.67200	
	1.00	1.25	2.78	3.47500	
	1.00	1.17	2.65	3.10050	
	1.00	1.2	2.30	2.76000	
	1.00	1.22	2.02	2.46440	
	1.00	1.27	1.65	2.09550	
	1.00	1.2	0.65	0.78000	
	1.00	0.9	0.78	0.70200	
DISCHARGE cfs				36.8	1.042
HEIGHT FROM BRIDGE(feet)				17.5	

Appendix 9. Discharge at Peralta Bridge

DATE	WIDTH feet	DEPTH feet	VELOCITY feet/sec	DISCHARGE cfs	DISCHARGE cms
04-24-00	1.50	0	0.00	0.00000	
	1.00	0.19	0.19	0.03610	
	1.00	0.4	0.22	0.08800	
	1.00	0.6	0.24	0.14400	
	1.00	0.9	0.30	0.27000	
	1.00	1.1	0.43	0.47300	
	1.00	1.25	0.41	0.51250	
	1.00	1.25	0.38	0.47500	
	1.00	1.2	0.45	0.54000	
	1.00	1.1	0.46	0.50600	
	1.00	0.92	0.51	0.46920	
	1.00	0.83	0.50	0.41500	
	1.00	0.7	0.53	0.37100	
	1.00	0.5	0.41	0.20500	
DISCHARGE cfs				4.5	0.128
HEIGHT FROM BRIDGE(feet)				18.4	

DATE	WIDTH feet	DEPTH feet	VELOCITY feet/sec	DISCHARGE cfs	DISCHARGE cms
05-01-00	1.50	0	0.00	0.00000	
	1.00	0	0.00	0.00000	
	1.00	0.30	0.01	0.00300	
	1.00	0.62	0.18	0.11160	
	1.00	0.9	0.23	0.20700	
	1.00	1.02	0.27	0.27540	
	1.00	1.2	0.30	0.36000	
	1.00	1.25	0.38	0.47500	
	1.00	1.25	0.38	0.47500	
	1.00	1.1	0.39	0.42900	
	1.00	0.97	0.42	0.40740	
	1.00	0.83	0.45	0.37350	
	1.00	0.67	0.47	0.31490	
	1.00	0.45	0.28	0.12600	
DISCHARGE cfs				3.6	0.101
HEIGHT FROM BRIDGE(feet)				18.1	

Appendix 9. Discharge at Peralta Bridge

DATE	WIDTH feet	DEPTH feet	VELOCITY feet/sec	DISCHARGE cfs	DISCHARGE cms
05-09-00	1.50	0	0.00	0.00000	
	1.00	0	0.00	0.00000	
	1.00	0.33	0.00	0.00000	
	1.00	0.58	0.01	0.00580	
	1.00	0.9	0.09	0.08100	
	1.00	1.1	0.19	0.20900	
	1.00	1.25	0.26	0.32500	
	1.00	1.45	0.30	0.43500	
	1.00	1.5	0.37	0.55500	
	1.00	1.42	0.48	0.68160	
	1.00	1.23	0.39	0.47970	
	1.00	1.12	0.58	0.64960	
	1.00	1.12	0.54	0.60480	
	1.00	0.94	0.49	0.46060	
DISCHARGE cfs				4.5	0.127
HEIGHT FROM BRIDGE(feet)				18.16	

DATE	WIDTH feet	DEPTH feet	VELOCITY feet/sec	DISCHARGE cfs	DISCHARGE cms
05/15/00	1.50	0	0.00	0.00000	
	1.00	0	0.00	0.00000	
	1.00	0.3	0.01	0.00300	
	1.00	0.64	0.01	0.00640	
	1.00	0.9	0.09	0.08100	
	1.00	1.1	0.15	0.16500	
	1.00	1.27	0.25	0.31750	
	1.00	1.42	0.26	0.36920	
	1.00	1.46	0.41	0.59860	
	1.00	1.4	0.34	0.47600	
	1.00	1.2	0.43	0.51600	
	1.00	1.14	0.50	0.57000	
	1.00	1	0.41	0.41000	
	1.00	0.84	0.54	0.45360	
DISCHARGE cfs				4.0	0.112
HEIGHT FROM BRIDGE(feet)				18.4	

Appendix 9. Discharge at Peralta Bridge

DATE	WIDTH feet	DEPTH feet	VELOCITY feet/sec	DISCHARGE cfs	DISCHARGE cms
05/22/00	1.50	0	0.00	0.00000	
	1.00	0	0.00	0.00000	
	1.00	0.25	N/A	0.25000	
	1.00	0.52	0.01	0.00520	
	1.00	0.78	0.01	0.00780	
	1.00	1.1	0.03	0.03300	
	1.00	1.25	0.10	0.12500	
	1.00	1.4	0.21	0.29400	
	1.00	1.39	0.24	0.33360	
	1.00	1.31	0.22	0.28820	
	1.00	1.2	0.26	0.31200	
	1.00	1.1	0.39	0.42900	
	1.00	0.95	0.34	0.32300	
	1.00	0.68	0.34	0.23120	
DISCHARGE cfs				2.6	0.075
HEIGHT FROM BRIDGE(feet)				18.3	

Appendix 9. Discharge at Peralta Bridge

DATE	WIDTH feet	DEPTH feet	VELOCITY feet/sec	DISCHARGE cfs	DISCHARGE cms
07-17-00	1.50	0.00	0.00	0.00000	
	1.00	0.00	0.00	0.00000	
	1.00	0.25	0.00	0.00000	
	1.00	0.45	0.01	0.00450	
	1.00	0.70	0.01	0.00700	
	1.00	0.90	0.04	0.03600	
	1.00	1.10	0.13	0.14300	
	1.00	1.20	0.15	0.18000	
	1.00	1.10	0.18	0.19800	
	1.00	1.00	0.17	0.17000	
	1.00	0.90	0.22	0.19800	
	1.00	0.83	0.17	0.14110	
	1.00	0.70	0.04	0.02800	
	1.00	0.35	0.16	0.05600	
DISCHARGE cfs				1.16	0.033
HEIGHT FROM BRIDGE(feet)				18.41	

DATE	WIDTH feet	DEPTH feet	VELOCITY feet/sec	DISCHARGE cfs	DISCHARGE cms
07-24-00	1.50	0.00	0.00	0.00000	
	1.00	0.00	0.00	0.00000	
	1.00	0.00	0.00	0.00000	
	1.00	0.25	0.00	0.00000	
	1.00	0.45	0.01	0.00450	
	1.00	0.64	0.01	0.00640	
	1.00	0.90	0.00	0.00000	
	1.00	1.00	0.04	0.04000	
	1.00	1.15	0.10	0.11500	
	1.00	1.15	0.12	0.13800	
	1.00	1.02	0.21	0.21420	
	1.00	0.90	0.21	0.18900	
	1.00	0.94	0.23	0.21620	
	1.00	0.75	0.19	0.14250	
DISCHARGE cfs				1.1	0.030
HEIGHT FROM BRIDGE(feet)				18.3	

Appendix 9. Discharge at Peralta Bridge

DATE	WIDTH feet	DEPTH feet	VELOCITY feet/sec	DISCHARGE cfs	DISCHARGE cms
07-31-00	1.50	0.00	0.00	0.00000	
	1.00	0.00	0.00	0.00000	
	1.00	0.25	0.00	0.00000	
	1.00	0.42	0.00	0.00000	
	1.00	0.60	0.02	0.01200	
	1.00	0.90	0.02	0.01800	
	1.00	1.00	0.08	0.08000	
	1.00	1.14	0.05	0.05700	
	1.00	1.14	0.09	0.10260	
	1.00	1.02	0.12	0.12240	
	1.00	0.95	0.13	0.12350	
	1.00	0.93	0.16	0.14880	
	1.00	0.75	0.18	0.13500	
	1.00	0.50	0.25	0.12500	
DISCHARGE cfs				0.924	0.026
HEIGHT FROM BRIDGE(feet)				18.25	

DATE	WIDTH feet	DEPTH feet	VELOCITY feet/sec	DISCHARGE cfs	DISCHARGE cms
08-07-00	1.50	0.00	0.00	0.00000	
	1.00	0.10	0.00	0.00000	
	1.00	0.25	0.00	0.00000	
	1.00	0.40	0.00	0.00000	
	1.00	0.62	0.02	0.01240	
	1.00	0.92	0.05	0.04600	
	1.00	1.00	0.11	0.11000	
	1.00	1.15	0.15	0.17250	
	1.00	1.12	0.11	0.12320	
	1.00	1.00	0.15	0.15000	
	1.00	0.87	0.19	0.16530	
	1.00	0.84	0.19	0.15960	
	1.00	0.70	0.17	0.11900	
	1.00	0.48	0.20	0.09600	
DISCHARGE cfs				1.2	0.033
HEIGHT FROM BRIDGE(feet)				18.25	

Appendix 9. Discharge at Peralta Bridge

DATE	WIDTH feet	DEPTH feet	VELOCITY feet/sec	DISCHARGE cfs	DISCHARGE cms
08-14-00	1.50	0.00	0.00	0.00000	
	1.00	0.00	0.00	0.00000	
	1.00	0.05	0.00	0.00000	
	1.00	0.20	0.00	0.00000	
	1.00	0.40	0.01	0.00400	
	1.00	0.60	0.01	0.00600	
	1.00	0.91	0.02	0.01820	
	1.00	1.00	0.06	0.06000	
	1.00	1.12	0.11	0.12320	
	1.00	1.12	0.10	0.11200	
	1.00	1.00	0.13	0.13000	
	1.00	0.85	0.16	0.13600	
	1.00	0.80	0.15	0.12000	
	1.00	0.68	0.14	0.09520	
DISCHARGE cfs				0.8	0.023
HEIGHT FROM BRIDGE(feet)				18.2	

Appendix 9. Discharge at Peralta Bridge

DATE	WIDTH feet	DEPTH feet	VELOCITY feet/sec	DISCHARGE cfs	DISCHARGE cms
10-16-00	1.50	0.00	0.00	0.00000	
	1.00	0.00	0.00	0.00000	
	1.00	0.25	0.01	0.00250	
	1.00	0.45	0.01	0.00450	
	1.00	0.72	0.01	0.00720	
	1.00	0.87	0.05	0.04350	
	1.00	1.00	0.08	0.08000	
	1.00	1.10	0.14	0.15400	
	1.00	0.95	0.15	0.14250	
	1.00	0.82	0.10	0.08200	
	1.00	0.75	0.12	0.09000	
	1.00	0.70	0.13	0.09100	
	1.00	0.40	0.14	0.05600	
	1.00	0.30	0.11	0.03300	
DISCHARGE cfs				0.79	0.022
HEIGHT FROM BRIDGE(feet)				18.2	

DATE	WIDTH feet	DEPTH feet	VELOCITY feet/sec	DISCHARGE cfs	DISCHARGE cms
10-23-00	1.50	0.00	0.00	0.00000	
	1.00	0.00	0.00	0.00000	
	1.00	0.00	0.00	0.00000	
	1.00	0.20	0.00	0.00000	
	1.00	0.40	0.01	0.00400	
	1.00	0.70	0.01	0.00700	
	1.00	0.82	0.07	0.05740	
	1.00	1.00	0.13	0.13000	
	1.00	1.09	0.09	0.09810	
	1.00	1.00	0.06	0.06000	
	1.00	0.82	0.05	0.04100	
	1.00	0.70	0.09	0.06300	
	1.00	0.70	0.13	0.09100	
	1.00	0.50	0.11	0.05500	
	1.00	0.32	0.20	0.06400	
DISCHARGE cfs				0.67	0.019
HEIGHT FROM BRIDGE(feet)				18.125	

Appendix 9. Discharge at Peralta Bridge

DATE	WIDTH feet	DEPTH feet	VELOCITY feet/sec	DISCHARGE cfs	DISCHARGE cms
10-30-00	1.50	0.43	0.07	0.04515	
	1.00	0.50	0.12	0.06000	
	1.00	0.45	0.16	0.07200	
	1.00	0.57	0.25	0.14250	
	1.00	0.77	0.28	0.21560	
	1.00	0.84	0.32	0.26880	
	1.00	0.80	0.40	0.32000	
	1.00	0.68	0.51	0.34680	
	1.00	0.70	0.51	0.35700	
	1.00	0.75	0.40	0.30000	
	1.00	0.93	0.48	0.44640	
	1.00	NA	NA	NA	
	1.00	NA	NA	NA	
	1.00	NA	NA	NA	
	1.00	NA	NA	NA	
DISCHARGE cfs				2.57	0.073
HEIGHT FROM BRIDGE(feet)				18.3	

DATE	WIDTH feet	DEPTH feet	VELOCITY feet/sec	DISCHARGE cfs	DISCHARGE cms
11-06-00	1.50	0.40	0.00	0.00000	
	1.00	0.33	0.00	0.00000	
	1.00	0.35	0.01	0.00350	
	1.00	0.40	0.01	0.00400	
	1.00	0.60	0.03	0.01800	
	1.00	0.70	0.11	0.07700	
	1.00	0.70	0.15	0.10500	
	1.00	0.60	0.22	0.13200	
	1.00	0.55	0.25	0.13750	
	1.00	0.62	0.21	0.13020	
	1.00	0.70	0.21	0.14700	
	1.00	0.83	0.27	0.22410	
	1.00	NA	NA	NA	
	1.00	NA	NA	NA	
	1.00	NA	NA	NA	
DISCHARGE cfs				0.98	0.028
HEIGHT FROM BRIDGE(feet)				18.25	

Appendix 9. Discharge at Peralta Bridge

DATE	WIDTH feet	DEPTH feet	VELOCITY feet/sec	DISCHARGE cfs	DISCHARGE cms
11-13-00	1.50	0.32	0.00	0.00000	
	1.00	0.30	0.00	0.00000	
	1.00	0.31	0.01	0.00310	
	1.00	0.32	0.01	0.00320	
	1.00	0.51	0.02	0.01020	
	1.00	0.61	0.05	0.03050	
	1.00	0.70	0.10	0.07000	
	1.00	0.62	0.08	0.04960	
	1.00	0.58	0.10	0.05800	
	1.00	0.60	0.08	0.04800	
	1.00	0.67	0.07	0.04690	
	1.00	0.78	0.08	0.06240	
	1.00	NA	NA	NA	
	1.00	NA	NA	NA	
	1.00	NA	NA	NA	
DISCHARGE cfs				0.38	0.011
HEIGHT FROM BRIDGE(feet)				18.2	

NA: Not Available

Appendix 10. Alkalinity Analyses

DATE	SITE	Va (Vol. Of acid used) ml	pH	Hf	Alkalinity (meq/L) (VaCa-Hf (Va+Vs))/Vs * 1000
02-22-00	Oddstad	15.5	3.90	0.000126	1.40
02-22-00	North Fork	52.8	3.88	0.000132	5.08
02-22-00	Linda Mar	28.7	3.69	0.000204	2.61
02-22-00	Peralta	36.3	3.89	0.000129	3.45
02-22-00	Outlet	37.8	3.87	0.000135	3.59
02-28-00	Oddstad	12.5	3.95	0.000112	1.12
02-28-00	North Fork	32.2	3.83	0.000148	3.02
02-28-00	Linda Mar	19.2	3.57	0.000269	1.60
02-28-00	Peralta	19.0	3.68	0.000209	1.65
02-28-00	Outlet	18.8	3.81	0.000155	1.70
04-24-00	Oddstad	18.0	3.95	0.000112	1.67
04-24-00	North Fork	59.4	3.87	0.000135	5.72
04-24-00	Linda Mar	34.3	3.69	0.000204	3.16
04-24-00	Peralta	31.2	3.81	0.000155	2.92
04-24-00	Outlet	25.5	3.81	0.000155	2.36
05-01-00	Oddstad	18.5	3.76	0.000174	1.64
05-01-00	North Fork	62.4	3.74	0.000182	5.94
05-01-00	Linda Mar	35.1	3.84	0.000145	3.31
05-01-00	Peralta	32.7	3.79	0.000162	3.05
05-01-00	Outlet	25.8	3.76	0.000174	2.36
05-09-00	Oddstad	18.5	3.85	0.000141	1.68
05-09-00	North Fork	50.0	3.83	0.000148	4.78
05-09-00	Linda Mar	31.4	3.94	0.000115	2.99
05-09-00	Peralta	30.7	3.84	0.000145	2.88
05-09-00	Outlet	25.9	3.83	0.000148	2.40
05-15-00	Oddstad	18.7	3.77	0.000170	1.67
05-15-00	North Fork	58.2	3.99	0.000102	5.66
05-15-00	Linda Mar	33.7	3.76	0.000174	3.14
05-15-00	Peralta	28.8	3.70	0.000200	2.62
05-15-00	Outlet	24.8	3.86	0.000138	2.31
05-22-00	Oddstad	18.1	3.82	0.000151	1.63
05-22-00	North Fork	63.9	3.84	0.000145	6.15
05-22-00	Linda Mar	33.6	3.98	0.000105	3.22
05-22-00	Peralta	34.5	3.6	0.000251	3.11
05-22-00	Outlet	24.7	3.92	0.000120	2.32
07-17-00	Oddstad	17.9	3.76	0.000174	1.59
07-17-00	North Fork	66.1	3.78	0.000166	6.33
07-17-00	Linda Mar	35.6	3.48	0.000331	3.11
07-17-00	Peralta	32.7	3.82	0.000151	3.07
07-17-00	Outlet	33.2	3.75	0.000178	3.08

Ca: Acid Concentration (0.01eq/L)

Vs: Sample Volume (100 mL)

Hf: Final H+ Concentration

Appendix 10. Alkalinity Analyses

DATE	SITE	Va (Vol. Of acid used) ml	pH	Hf	Alkalinity (meq/L) (VaCa-Hf (Va+Vs))/Vs * 1000
07-24-00	Oddstad	17.4	3.76	0.000174	1.54
07-24-00	North Fork	58.7	3.89	0.000129	5.67
07-24-00	Linda Mar	34.1	3.69	0.000204	3.14
07-24-00	Peralta	33.7	3.68	0.000209	3.09
07-24-00	Outlet	33.2	3.76	0.000174	3.09
07-31-00	Oddstad	28.5	3.63	0.000234	2.55
07-31-00	North Fork	70.0	3.97	0.000107	6.82
07-31-00	Linda Mar	42.5	3.75	0.000178	4.00
07-31-00	Peralta	33.0	3.79	0.000162	3.08
07-31-00	Outlet	30.0	3.67	0.000214	2.72
08-07-00	Oddstad	18.7	3.51	0.000309	1.50
08-07-00	North Fork	64.2	3.58	0.000263	5.99
08-07-00	Linda Mar	32.3	3.80	0.000158	3.02
08-07-00	Peralta	22.0	3.80	0.000158	2.01
08-07-00	Outlet	24.0	3.60	0.000251	2.09
08-14-00	Oddstad	18.4	3.85	0.000141	1.67
08-14-00	North Fork	44.0	3.91	0.000123	4.22
08-14-00	Linda Mar	20.6	3.11	0.000776	1.12
08-14-00	Peralta	20.5	3.23	0.000589	1.34
08-14-00	Outlet	18.5	3.25	0.000562	1.18
10-16-00	Oddstad	0.4	3.98	0.000105	3.89
10-16-00	North Fork	1.0	3.40	0.000398	9.60
10-16-00	Linda Mar	0.5	3.00	0.001000	4.00
10-16-00	Peralta	0.6	3.00	0.001000	4.99
10-16-00	Outlet	0.5	3.21	0.000617	4.38
10-23-00	Oddstad	0.2	3.46	0.000347	1.65
10-23-00	North Fork	0.8	3.7	0.000200	7.80
10-23-00	Linda Mar	0.3	3.1	0.000794	2.20
10-23-00	Peralta	0.4	3.68	0.000209	3.79
10-23-00	Outlet	0.4	3.22	0.000603	3.40
10-30-00	Oddstad	0.3	3.03	0.000933	2.06
10-30-00	North Fork	0.6	3.32	0.000479	5.52
10-30-00	Linda Mar	0.5	3.32	0.000479	4.52
10-30-00	Peralta	0.3	3.89	0.000129	2.87
10-30-00	Outlet	0.4	3.39	0.000407	3.59
11-06-00	Oddstad	0.3	3.00	0.001000	2.00
11-06-00	North Fork	0.8	3.42	0.000380	7.62
11-06-00	Linda Mar	0.5	3.10	0.000794	4.20
11-06-00	Peralta	0.4	3.74	0.000182	3.82
11-06-00	Outlet	0.5	3.00	0.001000	4.00
11-13-00	Oddstad	0.2	3.00	0.001000	1.00
11-13-00	North Fork	0.7	3.07	0.000851	6.14
11-13-00	Linda Mar	0.3	3.48	0.000331	2.67
11-13-00	Peralta	0.3	3.78	0.000166	2.83
11-13-00	Outlet	0.4	3.00	0.001000	3.00

Ca: Acid Concentration (0.01eq/L)

Vs: Sample Volume (100 mL)

Hf: Final H+ Concentration

Appendix 11. Hardness Analyses

DATE	SITE	Amount of titrated used in mL	Sample Volume (mL)	HARDNESS mg CaCO ₃ /L
07-17-00	Oddstad	7.9	25	316
07-17-00	North Fork	11.6	25	464
07-17-00	Linda Mar	11.0	25	440
07-17-00	Peralta	10.7	25	428
07-17-00	Parking lot	11.4	25	456
07-17-00	Outlet	NS	NS	NS
07-17-00	Beach	NS	NS	NS
07-24-00	Oddstad	36.0	25	1440
07-24-00	North Fork	42.0	25	1680
07-24-00	Linda Mar	27.5	25	1100
07-24-00	Peralta	20.0	25	800
07-24-00	Outlet	36.0	25	1440
07-24-00	Beach	NS	NS	NS
07-24-00	Parking lot	NS	NS	NS
07-31-00	Oddstad	14.2	25	568
07-31-00	North Fork	18.5	25	740
07-31-00	Linda Mar	13.3	25	532
07-31-00	Peralta	13.6	25	544
07-31-00	Outlet	11.5	25	460
07-31-00	Beach	NS	NS	NS
07-31-00	Parking lot	NS	NS	NS
08-07-00	Oddstad	11.5	25	460
08-07-00	North Fork	29.5	25	1180
08-07-00	Linda Mar	14.5	25	580
08-07-00	Peralta	11.0	25	440
08-07-00	Outlet	13.0	25	520
08-07-00	Beach	NS	NS	NS
08-07-00	Parking lot	NS	NS	NS
08-14-00	Oddstad	14.1	25	564
08-14-00	North Fork	19.0	25	760
08-14-00	Linda Mar	16.0	25	640
08-14-00	Peralta	18.5	25	740
08-14-00	Outlet	17.0	25	680
08-14-00	Beach	NS	NS	NS
08-14-00	Parking lot	NS	NS	NS

NS: No Sampled

Appendix 11. Hardness Analyses

DATE	SITE	Amount of titrated used in mL	Sample Volume (mL)	HARDNESS mg CaCO ₃ /L
10-16-00	Oddstad	12.5	25	500
10-16-00	North Fork	24.3	25	972
10-16-00	Linda Mar	23.0	25	920
10-16-00	Peralta	22.5	25	900
10-16-00	Outlet	24.0	25	960
10-16-00	Beach	NS	NS	NS
10-16-00	Parking lot	NS	NS	NS
10-23-00	Oddstad	11.2	25	448
10-23-00	North Fork	14.9	25	596
10-23-00	Linda Mar	11.8	25	472
10-23-00	Peralta	12.3	25	492
10-23-00	Parking lot	13.3	25	532
10-23-00	Outlet	NS	NS	NS
10-23-00	Beach	NS	NS	NS
10-30-00	Oddstad	11.3	25	452
10-30-00	North Fork	13.5	25	540
10-30-00	Linda Mar	12.3	25	492
10-30-00	Peralta	13.1	25	524
10-30-00	Outlet	11.8	25	472
10-30-00	Beach	NS	NS	NS
10-30-00	Parking lot	NS	NS	NS
11-06-00	Oddstad	12.7	25	508
11-06-00	North Fork	23.1	25	924
11-06-00	Linda Mar	14.3	25	572
11-06-00	Peralta	14.0	25	560
11-06-00	Outlet	16.0	25	640
11-06-00	Beach	NS	NS	NS
11-06-00	Parking lot	NS	NS	NS
11-13-00	Oddstad	12	25	480
11-13-00	North Fork	18	25	720
11-13-00	Linda Mar	13	25	520
11-13-00	Peralta	11.0	25	440
11-13-00	Outlet	10.5	25	420
11-13-00	Beach	NS	NS	NS
11-13-00	Parking lot	NS	NS	NS

Appendix 12. Metals Analyses

DATE	SITE	PARAMETER	RESULTS mg/L
04/24/00	Oddstad	Mercury	ND
		Antimony	ND
		Arsenic	ND
		Barium	ND
		Beryllium	ND
		Cadmium	ND
		Chromium	ND
		Cobalt	ND
		Copper	ND
		Lead	ND
		Molybdenum	ND
		Nickel	ND
		Selenium	ND
		Silver	ND
		Thallium	ND
		Vanadium	ND
		Zinc	ND
04/24/00	North Fork	Mercury	ND
		Antimony	ND
		Arsenic	ND
		Barium	ND
		Beryllium	ND
		Cadmium	ND
		Chromium	ND
		Cobalt	ND
		Copper	ND
		Lead	ND
		Molybdenum	ND
		Nickel	ND
		Selenium	ND
		Silver	ND
		Thallium	ND
		Vanadium	ND
		Zinc	0.0102

ND: No Determined

Appendix 12. Metals Analyses

DATE	SITE	PARAMETER	RESULTS mg/L
1/5/2000	Oddstad	Mercury	ND
		Antimony	ND
		Arsenic	ND
		Barium	ND
		Beryllium	ND
		Cadmium	ND
		Chromium	ND
		Cobalt	ND
		Copper	ND
		Lead	ND
		Molybdenum	ND
		Nickel	ND
		Selenium	ND
		Silver	ND
		Thallium	ND
		Vanadium	ND
		Zinc	ND
1/5/2000	North Fork	Mercury	ND
		Antimony	ND
		Arsenic	ND
		Barium	ND
		Beryllium	ND
		Cadmium	ND
		Chromium	ND
		Cobalt	ND
		Copper	ND
		Lead	ND
		Molybdenum	ND
		Nickel	ND
		Selenium	ND
		Silver	ND
		Thallium	ND
		Vanadium	ND
		Zinc	ND

Appendix 12. Metals Analyses

[illegible]

Appendix 12. Metals Analyses

DATE	SITE	PARAMETER	RESULTS mg/L
05/15/00	Oddstad	Mercury	ND
		Antimony	ND
		Arsenic	ND
		Barium	ND
		Beryllium	ND
		Cadmium	ND
		Chromium	ND
		Cobalt	ND
		Copper	ND
		Lead	ND
		Molybdenum	ND
		Nickel	ND
		Selenium	ND
		Silver	ND
		Thallium	ND
		Vanadium	ND
		Zinc	ND
05/15/00	North Fork	Mercury	ND
		Antimony	ND
		Arsenic	ND
		Barium	ND
		Beryllium	ND
		Cadmium	ND
		Chromium	ND
		Cobalt	ND
		Copper	ND
		Lead	ND
		Molybdenum	ND
		Nickel	ND
		Selenium	ND
		Silver	ND
		Thallium	ND
		Vanadium	ND
		Zinc	0.0123

Appendix 12. Metals Analyses

DATE	SITE	PARAMETER	RESULTS mg/L
05/22/00	Oddstad	Mercury	ND
		Antimony	ND
		Arsenic	ND
		Barium	ND
		Beryllium	ND
		Cadmium	ND
		Chromium	ND
		Cobalt	ND
		Copper	ND
		Lead	ND
		Molybdenum	ND
		Nickel	ND
		Selenium	ND
		Silver	ND
		Thallium	ND
		Vanadium	ND
		Zinc	ND
05/22/00	North Fork	Mercury	ND
		Antimony	ND
		Arsenic	ND
		Barium	ND
		Beryllium	ND
		Cadmium	ND
		Chromium	ND
		Cobalt	ND
		Copper	ND
		Lead	ND
		Molybdenum	ND
		Nickel	ND
		Selenium	ND
		Silver	ND
		Thallium	ND
		Vanadium	ND
		Zinc	0.0139

Appendix 13. Volatile Organic Compounds analyses

DATE	SITE	PARAMETER mg/L	RESULTS mg/L
04/24/00	Oddstad	Benzene	ND
		2-Butane	ND
		Carbon tetrachloride	ND
		Chlorobenzene	ND
		Chloroform	ND
		1,2-Dichloroethane	ND
		1,1-Dichloroethane	ND
		Tetrachloroethane	ND
		Trichloroethane	ND
		Vinyl chloride	ND
		1,2-Dichloroethane-d4	ND
		Toluene-d8	ND
		4-BFB	ND
04/24/00	North Fork	Benzene	ND
		2-Butane	ND
		Carbon tetrachloride	ND
		Chlorobenzene	ND
		Chloroform	ND
		1,2-Dichloroethane	ND
		1,1-Dichloroethane	ND
		Tetrachloroethane	ND
		Trichloroethane	ND
		Vinyl chloride	ND
		1,2-Dichloroethane-d4	ND
		Toluene-d8	ND
		4-BFB	ND
1/5/2000	Oddstad	Benzene	ND
		2-Butane	ND
		Carbon tetrachloride	ND
		Chlorobenzene	ND
		Chloroform	ND
		1,2-Dichloroethane	ND
		1,1-Dichloroethane	ND
		Tetrachloroethane	ND
		Trichloroethane	ND
		Vinyl chloride	ND
		1,2-Dichloroethane-d4	ND
		Toluene-d8	ND
		4-BFB	ND

ND: No Determined

Appendix 13. Volatile Organic Compounds analyses

DATE	SITE	PARAMETER mg/L	RESULTS mg/L
1/5/2000	North Fork	Benzene	ND
		2-Butane	ND
		Carbon tetrachloride	ND
		Chlorobenzene	ND
		Chloroform	ND
		1,2-Dichloroethane	ND
		1,1-Dichloroethane	ND
		Tetrachloroethane	ND
		Trichloroethane	ND
		Vinyl chloride	ND
		1,2-Dichloroethane-d4	ND
		Toluene-d8	ND
		4-BFB	ND
9/5/2000	Oddstad	Benzene	ND
		2-Butane	ND
		Carbon tetrachloride	ND
		Chlorobenzene	ND
		Chloroform	ND
		1,2-Dichloroethane	ND
		1,1-Dichloroethane	ND
		Tetrachloroethane	ND
		Trichloroethane	ND
		Vinyl chloride	ND
		1,2-Dichloroethane-d4	ND
		Toluene-d8	ND
		4-BFB	ND
9/5/2000	North Fork	Benzene	ND
		2-Butane	ND
		Carbon tetrachloride	ND
		Chlorobenzene	ND
		Chloroform	ND
		1,2-Dichloroethane	ND
		1,1-Dichloroethane	ND
		Tetrachloroethane	ND
		Trichloroethane	ND
		Vinyl chloride	ND
		1,2-Dichloroethane-d4	ND
		Toluene-d8	ND
		4-BFB	ND

Appendix 13. Volatile Organic Compounds analyses

DATE	SITE	PARAMETER mg/L	RESULTS mg/L
05/14/00	Oddstad	Benzene	ND
		2-Butane	ND
		Carbon tetrachloride	ND
		Chlorobenzene	ND
		Chloroform	ND
		1,2-Dichloroethane	ND
		1,1-Dichloroethane	ND
		Tetrachloroethane	ND
		Trichloroethane	ND
		Vinyl chloride	ND
		1,2-Dichloroethane-d4	ND
		Toluene-d8	ND
		4-BFB	ND
05/14/00	North Fork	Benzene	ND
		2-Butane	ND
		Carbon tetrachloride	ND
		Chlorobenzene	ND
		Chloroform	ND
		1,2-Dichloroethane	ND
		1,1-Dichloroethane	ND
		Tetrachloroethane	ND
		Trichloroethane	ND
		Vinyl chloride	ND
		1,2-Dichloroethane-d4	ND
		Toluene-d8	ND
		4-BFB	ND
05/22/00	Oddstad	Benzene	ND
		2-Butane	ND
		Carbon tetrachloride	ND
		Chlorobenzene	ND
		Chloroform	ND
		1,2-Dichloroethane	ND
		1,1-Dichloroethane	ND
		Tetrachloroethane	ND
		Trichloroethane	ND
		Vinyl chloride	ND
		1,2-Dichloroethane-d4	ND
		Toluene-d8	ND
		4-BFB	ND

Appendix 13. Volatile Organic Compounds analyses

DATE	SITE	PARAMETER mg/L	RESULTS mg/L
05/22/00	North Fork	Benzene	ND
		2-Butane	ND
		Carbon tetrachloride	ND
		Chlorobenzene	ND
		Chloroform	ND
		1,2-Dichloroethane	ND
		1,1-Dichloroethane	ND
		Tetrachloroethane	ND
		Trichloroethane	ND
		Vinyl chloride	ND
		1,2-Dichloroethane-d4	ND
		Toluene-d8	ND
		4-BFB	ND

Appendix 14. Bacteriological Analyses-EPA

DATE	SITE	TOTAL COLIFORMS MPN/100 mL	<i>Escherichia Coli</i> MPN/100 mL	Enterococci MPN/100 mL
01-24-00	Oddstad	8800	160	more than 24000
01-24-00	North Fork	NA	NA	NA
01-24-00	Linda Mar	29000	1500	more than 24000
01-24-00	Peralta	46000	2800	more than 24000
01-24-00	Outlet	61000	3000	more than 24000
01-24-00	Beach	37000	3600	8700
01-24-00	Parking lot	17000	1800	3300
01-31-00	Oddstad	740	100	less than 10
01-31-00	North Fork	12000	410	380
01-31-00	Linda Mar	3400	100	170
01-31-00	Peralta	12000	1100	770
01-31-00	Outlet	19000	1600	750
01-31-00	Beach	2000	200	710
01-31-00	Parking lot	520	410	370
02-07-00	Oddstad	2400.000	63	3.1
02-07-00	North Fork	3500	100	280
02-07-00	Linda Mar	2000	less than 10	63
02-07-00	Peralta	9600	100	230
02-07-00	Outlet	6300	310	240
02-07-00	Beach	3400	170	110
02-07-00	Parking lot	990	41	10
02-14-00	Oddstad	2600	140	less than 10
02-14-00	North Fork	6900	980	880
02-14-00	Linda Mar	5300	410	250
02-14-00	Peralta	9900	740	440
02-14-00	Outlet	24000	850	630
02-14-00	Beach	12000	1200	2900
02-14-00	Parking lot	880	52	63
02-22-00	Oddstad	860	31	6
02-22-00	North Fork	4200	160	59
02-22-00	Linda Mar	1300	150	32
02-22-00	Peralta	4100	790	63
02-22-00	Outlet	12000	11000	71
02-22-00	Beach	6900	5700	120
02-22-00	Parking lot	31	less than 10	10
02-28-00	Oddstad	1300	20	3
02-28-00	North Fork	2900	74	63
02-28-00	Linda Mar	2400	51	52
02-28-00	Peralta	6900	230	62
02-28-00	Outlet	ns	ns	1300
02-28-00	Beach	ns	ns	110
02-28-00	Parking lot	ns	ns	less than 10

NA: Not Available

Appendix 14. Bacteriological Analyses-EPA

DATE	SITE	TOTAL COLIFORMS MPN/100 mL	<i>Escherichia Coli</i> MPN/100 mL	Enterococci MPN/100 mL
04-24-00	Oddstad	1500	5	NA
04-24-00	North Fork	22000	510	NA
04-24-00	Linda Mar	3600	less than 100	NA
04-24-00	Peralta	7000	1200	NA
04-24-00	Outlet	8200	1700	NA
04-24-00	Beach	270	74	20
04-24-00	Parking lot	less than 10	less than 10	less than 10
05-01-00	Oddstad	2400	14	NA
05-01-00	North Fork	5600	200	NA
05-01-00	Linda Mar	4000	74	NA
05-01-00	Peralta	13000	1500	NA
05-01-00	Outlet	14000	3600	NA
05-01-00	Beach	240	130	10 D
05-01-00	Parking lot	31	less than 10	less than 10
05-09-00	Oddstad	410	20	NA
05-09-00	North Fork	More than 240000	27000	NA
05-09-00	Linda Mar	39000	3000	NA
05-09-00	Peralta	4600	740	NA
05-09-00	Outlet	6900	860	NA
05-09-00	Beach	290	41	10
05-09-00	Parking lot	130	30	10
05-15-00	Oddstad	850	70	NA
05-15-00	North Fork	19000	630	NA
05-15-00	Linda Mar	6900	100	NA
05-15-00	Peralta	13000	1200	NA
05-15-00	Outlet	25000	3000	NA
05-15-00	Beach	4100	460	310
05-15-00	Parking lot	930	97	98
05-22-00	Oddstad	2400	120	NA
05-22-00	North Fork	13000	120	NA
05-22-00	Linda Mar	9800	200	NA
05-22-00	Peralta	9200	990	NA
05-22-00	Outlet	9200	800	NA
05-22-00	Beach	1700	96	200
05-22-00	Parking lot	31	less than 10	less than 10

Appendix 14. Bacteriological Analyses EPA

DATE	SITE	TOTAL COLIFORMS MPN/100 mL	<i>Escherichia Coli</i> MPN/100 mL	Enterococci MPN/100 mL
07-17-00	Oddstad	2300	170	NA
07-17-00	North Fork	69000	390	NA
07-17-00	Linda Mar	17000	340	NA
07-17-00	Peralta	5900	980	NA
07-17-00	Outlet	10000	1700	NA
07-17-00	Beach	52	10	10
07-17-00	Parking lot	20	20	50
07-24-00	Oddstad	NA	NA	NA
07-24-00	North Fork	NA	NA	NA
07-24-00	Linda Mar	NA	NA	NA
07-24-00	Peralta	NA	NA	NA
07-24-00	Outlet	NA	NA	NA
07-24-00	Beach	NA	NA	NR
07-24-00	Parking lot	NA	NA	10
07-31-00	Oddstad	1800	41	NA
07-31-00	North Fork	24000	300	NA
07-31-00	Linda Mar	20000	120	NA
07-31-00	Peralta	11000	2500	NA
07-31-00	Outlet	10000	1700	NA
07-31-00	Beach	74	20	10
07-31-00	Parking lot	10	10	20
08-07-00	Oddstad	2400	130	NA
08-07-00	North Fork	24000	1900	NA
08-07-00	Linda Mar	24000	740	NA
08-07-00	Peralta	12000	6100	NA
08-07-00	Outlet	14000	6100	NA
08-07-00	Beach	4900	860	260
08-07-00	Parking lot	430	10	10
08-14-00	Oddstad	1200	170	NA
08-14-00	North Fork	24000	230	NA
08-14-00	Linda Mar	6500	340	NA
08-14-00	Peralta	6900	2100	NA
08-14-00	Outlet	6100	1400	NA
08-14-00	Beach	85	10	30
08-14-00	Parking lot	20	10	10

Appendix 14. Bacteriological Analyses-EPA

DATE	SITE	TOTAL COLIFORMS MPN/100 mL	<i>Escherichia Coll</i> MPN/100 mL	Enterococci MPN/100 mL
10-16-00	Oddstad	1500	31	NA
10-16-00	North Fork	11000	230	NA
10-16-00	Linda Mar	9200	170	NA
10-16-00	Peralta	9200	1900	NA
10-16-00	Outlet	13000	600	NA
10-16-00	Beach	3300	190	85
10-16-00	Parking lot	74	10	10
10-23-00	Oddstad	500	20	NA
10-23-00	North Fork	4600	170	NA
10-23-00	Linda Mar	1700	160	NA
10-23-00	Peralta	24000	13000	NA
10-23-00	Outlet	5800	450	NA
10-23-00	Beach	470	74	20
10-23-00	Parking lot	140	31	10
10-30-00	Oddstad	2200	41	NA
10-30-00	North Fork	24000	6500	NA
10-30-00	Linda Mar	24000	4600	NA
10-30-00	Peralta	24000	3600	NA
10-30-00	Outlet	24000	3200	NA
10-30-00	Beach	13000	730	1100
10-30-00	Parking lot	190	41	52
11-06-00	Oddstad	1200	31	NA
11-06-00	North Fork	6900	170	NA
11-06-00	Linda Mar	3400	62	NA
11-06-00	Peralta	4600	120	NA
11-06-00	Outlet	8700	340	NA
11-06-00	Beach	1300	74	220
11-06-00	Parking lot	630	20	20
11- 13- 00	Oddstad	680	20	NA
11- 13- 00	North Fork	9800	10	NA
11- 13- 00	Linda Mar	4100	31	NA
11- 13- 00	Peralta	3100	210	NA
11- 13- 00	Outlet	5500	300	NA
11- 13- 00	Beach	730	74	52
11- 13- 00	Parking lot	10	10	10

Appendix 15. Bacteriological Analyses
San Mateo County Health Department

DATE	SITE	TOTAL COLIFORMS	FECAL COLIFORMS	<i>Escherichia</i> <i>Coli</i>
		per 100 ml	per 100 ml	per 100 ml
01-24-00	Oddstad	NO SAMPLE	NO SAMPLE	NO DATA
01-24-00	North Fork	NO SAMPLE	NO SAMPLE	NO DATA
01-24-00	Linda Mar	NO SAMPLE	NO SAMPLE	NO DATA
01-24-00	Peralta	NO SAMPLE	NO SAMPLE	NO DATA
01-24-00	Outlet	NO SAMPLE	NO SAMPLE	NO DATA
01-24-00	Beach	NO SAMPLE	NO SAMPLE	NO DATA
01-24-00	Parking lot	NO SAMPLE	NO SAMPLE	NO DATA
01-31-00	Oddstad	80	20	NO DATA
01-31-00	North Fork	1.100	330	NO DATA
01-31-00	Linda Mar	1.700	490	NO DATA
01-31-00	Peralta	790	230	NO DATA
01-31-00	Outlet	5.400	1300	NO DATA
01-31-00	Beach	330	110	NO DATA
01-31-00	Parking lot	less than 20	less than 20	NO DATA
02-07-00	Oddstad	80	80	NO DATA
02-07-00	North Fork	1.400	1.100	NO DATA
02-07-00	Linda Mar	330	130	NO DATA
02-07-00	Peralta	3.500	1.700	NO DATA
02-07-00	Outlet	460	310	NO DATA
02-07-00	Beach	790	310	NO DATA
02-07-00	Parking lot	2.200	1.100	NO DATA
02-14-00	Oddstad	230	230	NO DATA
02-14-00	North Fork	2.200	700	NO DATA
02-14-00	Linda Mar	1.300	330	NO DATA
02-14-00	Peralta	2.200	950	NO DATA
02-14-00	Outlet	5.400	1.700	NO DATA
02-14-00	Beach	2.400	330	NO DATA
02-14-00	Parking lot	130	50	NO DATA
02-22-00	Oddstad	20	less than 20	NO DATA
02-22-00	North Fork	2.400	790	NO DATA
02-22-00	Linda Mar	1.600	490	NO DATA
02-22-00	Peralta	1.100	490	NO DATA
02-22-00	Outlet	9.200	1.300	NO DATA
02-22-00	Beach	2.400	less than 20	NO DATA
02-22-00	Parking lot	less than 20	1.700	NO DATA
02-28-00	Oddstad	80	80	NO DATA
02-28-00	North Fork	1.700	1.100	NO DATA
02-28-00	Linda Mar	490	330	NO DATA
02-28-00	Peralta	950	640	NO DATA
02-28-00	Outlet	1.100	700	NO DATA
02-28-00	Beach	170	130	NO DATA
02-28-00	Parking lot	2.800	1.400	NO DATA

Appendix 15. Bacteriological Analysis
San Mateo County Health Department

DATE	SITE	TOTAL COLIFORMS	FECAL COLIFORMS	<i>Escherichia</i> <i>Coli</i>
		per 100 ml	per 100 ml	per 100 ml
04-24-00	Oddstad	80	20	20
04-24-00	North Fork	1.300	490	490
04-24-00	Linda Mar	1.100	330	230
04-24-00	Peralta	24000	16.000	16.000
04-24-00	Outlet	1.400	950	640
04-24-00	Beach	80	20	20
04-24-00	Parking lot	20	20	20
05-01-00	Oddstad	260	170	NO DATA
05-01-00	North Fork	1.100	460	NO DATA
05-01-00	Linda Mar	3.500	700	NO DATA
05-01-00	Peralta	3.500	490	NO DATA
05-01-00	Outlet	230	230	NO DATA
05-01-00	Beach	230	80	NO DATA
05-01-00	Parking lot	20	20	NO DATA
05-09-00	Oddstad	170	110	NO DATA
05-09-00	North Fork	24000	24000	NO DATA
05-09-00	Linda Mar	24000	16.000	NO DATA
05-09-00	Peralta	1.400	950	NO DATA
05-09-00	Outlet	3.500	2.800	NO DATA
05-09-00	Beach	170	170	NO DATA
05-09-00	Parking lot	130	130	NO DATA
05-15-00	Oddstad	330	170	NO DATA
05-15-00	North Fork	2.800	1.400	NO DATA
05-15-00	Linda Mar	2.200	1.100	NO DATA
05-15-00	Peralta	9.200	2.200	NO DATA
05-15-00	Outlet	16.000	2.400	NO DATA
05-15-00	Beach	2.200	790	NO DATA
05-15-00	Parking lot	170	50	NO DATA
05-22-00	Oddstad	140	110	NO DATA
05-22-00	North Fork	3.500	1.700	NO DATA
05-22-00	Linda Mar	2.200	1.300	NO DATA
05-22-00	Peralta	1.400	460	NO DATA
05-22-00	Outlet	1.400	460	NO DATA
05-22-00	Beach	700	310	NO DATA
05-22-00	Parking lot	20	20	NO DATA

Appendix 15. Bacteriological Analysis
San Mateo County Health Department

DATE	SITE	TOTAL COLIFORMS	FECAL COLIFORMS	<i>Escherichia Coli</i>
		per 100 ml	per 100 ml	per 100 ml
07-17-00	Oddstad	1379	135	NO DATA
07-17-00	North Fork	9804	259	NO DATA
07-17-00	Linda Mar	8664	346	NO DATA
07-17-00	Peralta	6488	886	NO DATA
07-17-00	Outlet	3448	1396	NO DATA
07-17-00	Beach	20	10	NO DATA
07-17-00	Parking lot	10	10	NO DATA
07-24-00	Oddstad	1043	41	NO DATA
07-24-00	North Fork	9804	576	NO DATA
07-24-00	Linda Mar	9208	613	NO DATA
07-24-00	Peralta	7701	1414	NO DATA
07-24-00	Outlet	6867	1211	NO DATA
07-24-00	Beach	1376	399	NO DATA
07-24-00	Parking lot	20	10	NO DATA
07-31-00	Oddstad	960	130	96
07-31-00	North Fork	2909	170	110
07-31-00	Linda Mar	6488	80	110
07-31-00	Peralta	3255	1300	1658
07-31-00	Outlet	2046	1300	1483
07-31-00	Beach	63	50	20
07-31-00	Parking lot	10	50	10
08-07-00	Oddstad	1143	110	175
08-07-00	North Fork	3873	1700	1098
08-07-00	Linda Mar	5475	1300	852
08-07-00	Peralta	6488	1800	1658
08-07-00	Outlet	2844	1300	1650
08-07-00	Beach	2987	1100	1284
08-07-00	Parking lot	10	less than 20	10
08-14-00	Oddstad	987	63	NO DATA
08-14-00	North Fork	5247	272	NO DATA
08-14-00	Linda Mar	2723	97	NO DATA
08-14-00	Peralta	4352	1313	NO DATA
08-14-00	Outlet	4106	884	NO DATA
08-14-00	Beach	41	10	NO DATA
08-14-00	Parking lot	20	10	NO DATA

Appendix 15. Bacteriological Analyses
San Mateo County Health Department

DATE	SITE	TOTAL COLIFORMS	FECAL COLIFORMS	<i>Escherichia Coli</i>
		per 100 ml	per 100 ml	per 100 ml
10-16-00	Oddstad	700	80	80
10-16-00	North Fork	790	170	130
10-16-00	Linda Mar	790	130	130
10-16-00	Peralta	1700	790	790
10-16-00	Outlet	1100	460	330
10-16-00	Beach	330	20	20
10-16-00	Parking lot	20	less than 20	less than 20
10-23-00	Oddstad	230	20	20
10-23-00	North Fork	700	170	170
10-23-00	Linda Mar	790	130	80
10-23-00	Peralta	16000	9200	3500
10-23-00	Outlet	1300	330	330
10-23-00	Beach	230	20	20
10-23-00	Parking lot	80	20	20
10-30-00	Oddstad	330	230	230
10-30-00	North Fork	16000	9200	5400
10-30-00	Linda Mar	9200	5400	5400
10-30-00	Peralta	9200	5400	2400
10-30-00	Outlet	5400	2400	2400
10-30-00	Beach	1300	490	490
10-30-00	Parking lot	130	50	50
11-06-00	Oddstad	490	50	50
11-06-00	North Fork	790	170	130
11-06-00	Linda Mar	700	80	80
11-06-00	Peralta	490	140	140
11-06-00	Outlet	790	330	230
11-06-00	Beach	330	130	130
11-06-00	Parking lot	700	50	50
11-13-00	Oddstad	490	20	20
11-13-00	North Fork	1300	140	110
11-13-00	Linda Mar	1300	130	130
11-13-00	Peralta	1400	230	230
11-13-00	Outlet	1100	230	130
11-13-00	Beach	490	50	50
11-13-00	Parking lot	20	20	20

Appendix 12. Metals Analyses

DATE	SITE	PARAMETER	RESULTS mg/L
9/5/2000	Oddstad	Mercury	ND
		Antimony	ND
		Arsenic	ND
		Barium	ND
		Beryllium	ND
		Cadmium	ND
		Chromium	ND
		Cobalt	ND
		Copper	ND
		Lead	ND
		Molybdenum	ND
		Nickel	ND
		Selenium	ND
		Silver	0.0604
		Thallium	ND
		Vanadium	ND
		Zinc	ND
9/5/2000	North Fork	Mercury	ND
		Antimony	ND
		Arsenic	ND
		Barium	ND
		Beryllium	ND
		Cadmium	ND
		Chromium	ND
		Cobalt	ND
		Copper	ND
		Lead	ND
		Molybdenum	ND
		Nickel	ND
		Selenium	ND
		Silver	ND
		Thallium	ND
		Vanadium	ND
		Zinc	0.0145

Appendix 12. Metals Analyses

[illegible]

Appendix 12. Metals Analyses

DATE	SITE	PARAMETER	RESULTS mg/L
05/22/00	Oddstad	Mercury	ND
		Antimony	ND
		Arsenic	ND
		Barium	ND
		Beryllium	ND
		Cadmium	ND
		Chromium	ND
		Cobalt	ND
		Copper	ND
		Lead	ND
		Molybdenum	ND
		Nickel	ND
		Selenium	ND
		Silver	ND
		Thallium	ND
		Vanadium	ND
		Zinc	ND
05/22/00	North Fork	Mercury	ND
		Antimony	ND
		Arsenic	ND
		Barium	ND
		Beryllium	ND
		Cadmium	ND
		Chromium	ND
		Cobalt	ND
		Copper	ND
		Lead	ND
		Molybdenum	ND
		Nickel	ND
		Selenium	ND
		Silver	ND
		Thallium	ND
		Vanadium	ND
		Zinc	0.0139

Appendix 13. Volatile Organic Compounds analyses

DATE	SITE	PARAMETER mg/L	RESULTS mg/L
04/24/00	Oddstad	Benzene	ND
		2-Butane	ND
		Carbon tetrachloride	ND
		Chlorobenzene	ND
		Chloroform	ND
		1,2-Dichloroethane	ND
		1,1-Dichloroethane	ND
		Tetrachloroethane	ND
		Trichloroethane	ND
		Vinyl chloride	ND
		1,2-Dichloroethane-d4	ND
		Toluene-d8	ND
		4-BFB	ND
04/24/00	North Fork	Benzene	ND
		2-Butane	ND
		Carbon tetrachloride	ND
		Chlorobenzene	ND
		Chloroform	ND
		1,2-Dichloroethane	ND
		1,1-Dichloroethane	ND
		Tetrachloroethane	ND
		Trichloroethane	ND
		Vinyl chloride	ND
		1,2-Dichloroethane-d4	ND
		Toluene-d8	ND
		4-BFB	ND
1/5/2000	Oddstad	Benzene	ND
		2-Butane	ND
		Carbon tetrachloride	ND
		Chlorobenzene	ND
		Chloroform	ND
		1,2-Dichloroethane	ND
		1,1-Dichloroethane	ND
		Tetrachloroethane	ND
		Trichloroethane	ND
		Vinyl chloride	ND
		1,2-Dichloroethane-d4	ND
		Toluene-d8	ND
		4-BFB	ND

ND: No Determined

Appendix 13. Volatile Organic Compounds analyses

DATE	SITE	PARAMETER mg/L	RESULTS mg/L
1/5/2000	North Fork	Benzene	ND
		2-Butane	ND
		Carbon tetrachloride	ND
		Chlorobenzene	ND
		Chloroform	ND
		1,2-Dichloroethane	ND
		1,1-Dichloroethane	ND
		Tetrachloroethane	ND
		Trichloroethane	ND
		Vinyl chloride	ND
		1,2-Dichloroethane-d4	ND
		Toluene-d8	ND
		4-BFB	ND
9/5/2000	Oddstad	Benzene	ND
		2-Butane	ND
		Carbon tetrachloride	ND
		Chlorobenzene	ND
		Chloroform	ND
		1,2-Dichloroethane	ND
		1,1-Dichloroethane	ND
		Tetrachloroethane	ND
		Trichloroethane	ND
		Vinyl chloride	ND
		1,2-Dichloroethane-d4	ND
		Toluene-d8	ND
		4-BFB	ND
9/5/2000	North Fork	Benzene	ND
		2-Butane	ND
		Carbon tetrachloride	ND
		Chlorobenzene	ND
		Chloroform	ND
		1,2-Dichloroethane	ND
		1,1-Dichloroethane	ND
		Tetrachloroethane	ND
		Trichloroethane	ND
		Vinyl chloride	ND
		1,2-Dichloroethane-d4	ND
		Toluene-d8	ND
		4-BFB	ND

Appendix 13. Volatile Organic Compounds analyses

DATE	SITE	PARAMETER mg/L	RESULTS mg/L
05/14/00	Oddstad	Benzene	ND
		2-Butane	ND
		Carbon tetrachloride	ND
		Chlorobenzene	ND
		Chloroform	ND
		1,2-Dichloroethane	ND
		1,1-Dichloroethane	ND
		Tetrachloroethane	ND
		Trichloroethane	ND
		Vinyl chloride	ND
		1,2-Dichloroethane-d4	ND
		Toluene-d8	ND
		4-BFB	ND
05/14/00	North Fork	Benzene	ND
		2-Butane	ND
		Carbon tetrachloride	ND
		Chlorobenzene	ND
		Chloroform	ND
		1,2-Dichloroethane	ND
		1,1-Dichloroethane	ND
		Tetrachloroethane	ND
		Trichloroethane	ND
		Vinyl chloride	ND
		1,2-Dichloroethane-d4	ND
		Toluene-d8	ND
		4-BFB	ND
05/22/00	Oddstad	Benzene	ND
		2-Butane	ND
		Carbon tetrachloride	ND
		Chlorobenzene	ND
		Chloroform	ND
		1,2-Dichloroethane	ND
		1,1-Dichloroethane	ND
		Tetrachloroethane	ND
		Trichloroethane	ND
		Vinyl chloride	ND
		1,2-Dichloroethane-d4	ND
		Toluene-d8	ND
		4-BFB	ND

Appendix 13. Volatile Organic Compounds analyses

DATE	SITE	PARAMETER mg/L	RESULTS mg/L
05/22/00	North Fork	Benzene	ND
		2-Butane	ND
		Carbon tetrachloride	ND
		Chlorobenzene	ND
		Chloroform	ND
		1,2-Dichloroethane	ND
		1,1-Dichloroethane	ND
		Tetrachloroethane	ND
		Trichloroethane	ND
		Vinyl chloride	ND
		1,2-Dichloroethane-d4	ND
		Toluene-d8	ND
		4-BFB	ND

Appendix 14. Bacteriological Analyses-EPA

DATE	SITE	TOTAL COLIFORMS MPN/100 mL	<i>Escherichia Coli</i> MPN/100 mL	Enterococci MPN/100 mL
01-24-00	Oddstad	8800	160	more than 24000
01-24-00	North Fork	NA	NA	NA
01-24-00	Linda Mar	29000	1500	more than 24000
01-24-00	Peralta	46000	2800	more than 24000
01-24-00	Outlet	61000	3000	more than 24000
01-24-00	Beach	37000	3600	8700
01-24-00	Parking lot	17000	1800	3300
01-31-00	Oddstad	740	100	less than 10
01-31-00	North Fork	12000	410	380
01-31-00	Linda Mar	3400	100	170
01-31-00	Peralta	12000	1100	770
01-31-00	Outlet	19000	1600	750
01-31-00	Beach	2000	200	710
01-31-00	Parking lot	520	410	370
02-07-00	Oddstad	2400.000	63	3.1
02-07-00	North Fork	3500	100	280
02-07-00	Linda Mar	2000	less than 10	63
02-07-00	Peralta	9600	100	230
02-07-00	Outlet	6300	310	240
02-07-00	Beach	3400	170	110
02-07-00	Parking lot	990	41	10
02-14-00	Oddstad	2600	140	less than 10
02-14-00	North Fork	6900	980	880
02-14-00	Linda Mar	5300	410	250
02-14-00	Peralta	9900	740	440
02-14-00	Outlet	24000	850	630
02-14-00	Beach	12000	1200	2900
02-14-00	Parking lot	880	52	63
02-22-00	Oddstad	860	31	6
02-22-00	North Fork	4200	160	59
02-22-00	Linda Mar	1300	150	32
02-22-00	Peralta	4100	790	63
02-22-00	Outlet	12000	11000	71
02-22-00	Beach	6900	5700	120
02-22-00	Parking lot	31	less than 10	10
02-28-00	Oddstad	1300	20	3
02-28-00	North Fork	2900	74	63
02-28-00	Linda Mar	2400	51	52
02-28-00	Peralta	6900	230	62
02-28-00	Outlet	ns	ns	1300
02-28-00	Beach	ns	ns	110
02-28-00	Parking lot	ns	ns	less than 10

NA: Not Available

Appendix 14. Bacteriological Analyses-EPA

DATE	SITE	TOTAL COLIFORMS MPN/100 mL	<i>Escherichia Coli</i> MPN/100 mL	Enterococci MPN/100 mL
04-24-00	Oddstad	1500	5	NA
04-24-00	North Fork	22000	510	NA
04-24-00	Linda Mar	3600	less than 100	NA
04-24-00	Peralta	7000	1200	NA
04-24-00	Outlet	8200	1700	NA
04-24-00	Beach	270	74	20
04-24-00	Parking lot	less than 10	less than 10	less than 10
05-01-00	Oddstad	2400	14	NA
05-01-00	North Fork	5600	200	NA
05-01-00	Linda Mar	4000	74	NA
05-01-00	Peralta	13000	1500	NA
05-01-00	Outlet	14000	3600	NA
05-01-00	Beach	240	130	10 D
05-01-00	Parking lot	31	less than 10	less than 10
05-09-00	Oddstad	410	20	NA
05-09-00	North Fork	More than 240000	27000	NA
05-09-00	Linda Mar	39000	3000	NA
05-09-00	Peralta	4600	740	NA
05-09-00	Outlet	6900	860	NA
05-09-00	Beach	290	41	10
05-09-00	Parking lot	130	30	10
05-15-00	Oddstad	850	70	NA
05-15-00	North Fork	19000	630	NA
05-15-00	Linda Mar	6900	100	NA
05-15-00	Peralta	13000	1200	NA
05-15-00	Outlet	25000	3000	NA
05-15-00	Beach	4100	460	310
05-15-00	Parking lot	930	97	98
05-22-00	Oddstad	2400	120	NA
05-22-00	North Fork	13000	120	NA
05-22-00	Linda Mar	9800	200	NA
05-22-00	Peralta	9200	990	NA
05-22-00	Outlet	9200	800	NA
05-22-00	Beach	1700	96	200
05-22-00	Parking lot	31	less than 10	less than 10

Appendix 14. Bacteriological Analyses EPA

DATE	SITE	TOTAL COLIFORMS MPN/100 mL	<i>Escherichia Coli</i> MPN/100 mL	Enterococci MPN/100 mL
07-17-00	Oddstad	2300	170	NA
07-17-00	North Fork	69000	390	NA
07-17-00	Linda Mar	17000	340	NA
07-17-00	Peralta	5900	980	NA
07-17-00	Outlet	10000	1700	NA
07-17-00	Beach	52	10	10
07-17-00	Parking lot	20	20	50
07-24-00	Oddstad	NA	NA	NA
07-24-00	North Fork	NA	NA	NA
07-24-00	Linda Mar	NA	NA	NA
07-24-00	Peralta	NA	NA	NA
07-24-00	Outlet	NA	NA	NA
07-24-00	Beach	NA	NA	NR
07-24-00	Parking lot	NA	NA	10
07-31-00	Oddstad	1800	41	NA
07-31-00	North Fork	24000	300	NA
07-31-00	Linda Mar	20000	120	NA
07-31-00	Peralta	11000	2500	NA
07-31-00	Outlet	10000	1700	NA
07-31-00	Beach	74	20	10
07-31-00	Parking lot	10	10	20
08-07-00	Oddstad	2400	130	NA
08-07-00	North Fork	24000	1900	NA
08-07-00	Linda Mar	24000	740	NA
08-07-00	Peralta	12000	6100	NA
08-07-00	Outlet	14000	6100	NA
08-07-00	Beach	4900	860	260
08-07-00	Parking lot	430	10	10
08-14-00	Oddstad	1200	170	NA
08-14-00	North Fork	24000	230	NA
08-14-00	Linda Mar	6500	340	NA
08-14-00	Peralta	6900	2100	NA
08-14-00	Outlet	6100	1400	NA
08-14-00	Beach	85	10	30
08-14-00	Parking lot	20	10	10

Appendix 14. Bacteriological Analyses-EPA

DATE	SITE	TOTAL COLIFORMS MPN/100 mL	<i>Escherichia Coli</i> MPN/100 mL	Enterococci MPN/100 mL
10-16-00	Oddstad	1500	31	NA
10-16-00	North Fork	11000	230	NA
10-16-00	Linda Mar	9200	170	NA
10-16-00	Peralta	9200	1900	NA
10-16-00	Outlet	13000	600	NA
10-16-00	Beach	3300	190	85
10-16-00	Parking lot	74	10	10
10-23-00	Oddstad	500	20	NA
10-23-00	North Fork	4600	170	NA
10-23-00	Linda Mar	1700	160	NA
10-23-00	Peralta	24000	13000	NA
10-23-00	Outlet	5800	450	NA
10-23-00	Beach	470	74	20
10-23-00	Parking lot	140	31	10
10-30-00	Oddstad	2200	41	NA
10-30-00	North Fork	24000	6500	NA
10-30-00	Linda Mar	24000	4600	NA
10-30-00	Peralta	24000	3600	NA
10-30-00	Outlet	24000	3200	NA
10-30-00	Beach	13000	730	1100
10-30-00	Parking lot	190	41	52
11-06-00	Oddstad	1200	31	NA
11-06-00	North Fork	6900	170	NA
11-06-00	Linda Mar	3400	62	NA
11-06-00	Peralta	4600	120	NA
11-06-00	Outlet	8700	340	NA
11-06-00	Beach	1300	74	220
11-06-00	Parking lot	630	20	20
11- 13- 00	Oddstad	680	20	NA
11- 13- 00	North Fork	9800	10	NA
11- 13- 00	Linda Mar	4100	31	NA
11- 13- 00	Peralta	3100	210	NA
11- 13- 00	Outlet	5500	300	NA
11- 13- 00	Beach	730	74	52
11- 13- 00	Parking lot	10	10	10

**Appendix 15. Bacteriological Analyses
San Mateo County Health Department**

DATE	SITE	TOTAL COLIFORMS	FECAL COLIFORMS	<i>Escherichia</i> <i>Coli</i>
		per 100 ml	per 100 ml	per 100 ml
01-24-00	Oddstad	NO SAMPLE	NO SAMPLE	NO DATA
01-24-00	North Fork	NO SAMPLE	NO SAMPLE	NO DATA
01-24-00	Linda Mar	NO SAMPLE	NO SAMPLE	NO DATA
01-24-00	Peralta	NO SAMPLE	NO SAMPLE	NO DATA
01-24-00	Outlet	NO SAMPLE	NO SAMPLE	NO DATA
01-24-00	Beach	NO SAMPLE	NO SAMPLE	NO DATA
01-24-00	Parking lot	NO SAMPLE	NO SAMPLE	NO DATA
01-31-00	Oddstad	80	20	NO DATA
01-31-00	North Fork	1.100	330	NO DATA
01-31-00	Linda Mar	1.700	490	NO DATA
01-31-00	Peralta	790	230	NO DATA
01-31-00	Outlet	5.400	1300	NO DATA
01-31-00	Beach	330	110	NO DATA
01-31-00	Parking lot	less than 20	less than 20	NO DATA
02-07-00	Oddstad	80	80	NO DATA
02-07-00	North Fork	1.400	1.100	NO DATA
02-07-00	Linda Mar	330	130	NO DATA
02-07-00	Peralta	3.500	1.700	NO DATA
02-07-00	Outlet	460	310	NO DATA
02-07-00	Beach	790	310	NO DATA
02-07-00	Parking lot	2.200	1.100	NO DATA
02-14-00	Oddstad	230	230	NO DATA
02-14-00	North Fork	2.200	700	NO DATA
02-14-00	Linda Mar	1.300	330	NO DATA
02-14-00	Peralta	2.200	950	NO DATA
02-14-00	Outlet	5.400	1.700	NO DATA
02-14-00	Beach	2.400	330	NO DATA
02-14-00	Parking lot	130	50	NO DATA
02-22-00	Oddstad	20	less than 20	NO DATA
02-22-00	North Fork	2.400	790	NO DATA
02-22-00	Linda Mar	1.600	490	NO DATA
02-22-00	Peralta	1.100	490	NO DATA
02-22-00	Outlet	9.200	1.300	NO DATA
02-22-00	Beach	2.400	less than 20	NO DATA
02-22-00	Parking lot	less than 20	1.700	NO DATA
02-28-00	Oddstad	80	80	NO DATA
02-28-00	North Fork	1.700	1.100	NO DATA
02-28-00	Linda Mar	490	330	NO DATA
02-28-00	Peralta	950	640	NO DATA
02-28-00	Outlet	1.100	700	NO DATA
02-28-00	Beach	170	130	NO DATA
02-28-00	Parking lot	2.800	1.400	NO DATA

Appendix 15. Bacteriological Analysis
San Mateo County Health Department

DATE	SITE	TOTAL COLIFORMS	FECAL COLIFORMS	<i>Escherichia</i> <i>Coli</i>
		per 100 ml	per 100 ml	per 100 ml
04-24-00	Oddstad	80	20	20
04-24-00	North Fork	1.300	490	490
04-24-00	Linda Mar	1.100	330	230
04-24-00	Peralta	24000	16.000	16.000
04-24-00	Outlet	1.400	950	640
04-24-00	Beach	80	20	20
04-24-00	Parking lot	20	20	20
05-01-00	Oddstad	260	170	NO DATA
05-01-00	North Fork	1.100	460	NO DATA
05-01-00	Linda Mar	3.500	700	NO DATA
05-01-00	Peralta	3.500	490	NO DATA
05-01-00	Outlet	230	230	NO DATA
05-01-00	Beach	230	80	NO DATA
05-01-00	Parking lot	20	20	NO DATA
05-09-00	Oddstad	170	110	NO DATA
05-09-00	North Fork	24000	24000	NO DATA
05-09-00	Linda Mar	24000	16.000	NO DATA
05-09-00	Peralta	1.400	950	NO DATA
05-09-00	Outlet	3.500	2.800	NO DATA
05-09-00	Beach	170	170	NO DATA
05-09-00	Parking lot	130	130	NO DATA
05-15-00	Oddstad	330	170	NO DATA
05-15-00	North Fork	2.800	1.400	NO DATA
05-15-00	Linda Mar	2.200	1.100	NO DATA
05-15-00	Peralta	9.200	2.200	NO DATA
05-15-00	Outlet	16.000	2.400	NO DATA
05-15-00	Beach	2.200	790	NO DATA
05-15-00	Parking lot	170	50	NO DATA
05-22-00	Oddstad	140	110	NO DATA
05-22-00	North Fork	3.500	1.700	NO DATA
05-22-00	Linda Mar	2.200	1.300	NO DATA
05-22-00	Peralta	1.400	460	NO DATA
05-22-00	Outlet	1.400	460	NO DATA
05-22-00	Beach	700	310	NO DATA
05-22-00	Parking lot	20	20	NO DATA

Appendix 15. Bacteriological Analysis
San Mateo County Health Department

DATE	SITE	TOTAL COLIFORMS	FECAL COLIFORMS	<i>Escherichia Coli</i>
		per 100 ml	per 100 ml	per 100 ml
07-17-00	Oddstad	1379	135	NO DATA
07-17-00	North Fork	9804	259	NO DATA
07-17-00	Linda Mar	8664	346	NO DATA
07-17-00	Peralta	6488	886	NO DATA
07-17-00	Outlet	3448	1396	NO DATA
07-17-00	Beach	20	10	NO DATA
07-17-00	Parking lot	10	10	NO DATA
07-24-00	Oddstad	1043	41	NO DATA
07-24-00	North Fork	9804	576	NO DATA
07-24-00	Linda Mar	9208	613	NO DATA
07-24-00	Peralta	7701	1414	NO DATA
07-24-00	Outlet	6867	1211	NO DATA
07-24-00	Beach	1376	399	NO DATA
07-24-00	Parking lot	20	10	NO DATA
07-31-00	Oddstad	960	130	96
07-31-00	North Fork	2909	170	110
07-31-00	Linda Mar	6488	80	110
07-31-00	Peralta	3255	1300	1658
07-31-00	Outlet	2046	1300	1483
07-31-00	Beach	63	50	20
07-31-00	Parking lot	10	50	10
08-07-00	Oddstad	1143	110	175
08-07-00	North Fork	3873	1700	1098
08-07-00	Linda Mar	5475	1300	852
08-07-00	Peralta	6488	1800	1658
08-07-00	Outlet	2844	1300	1650
08-07-00	Beach	2987	1100	1284
08-07-00	Parking lot	10	less than 20	10
08-14-00	Oddstad	987	63	NO DATA
08-14-00	North Fork	5247	272	NO DATA
08-14-00	Linda Mar	2723	97	NO DATA
08-14-00	Peralta	4352	1313	NO DATA
08-14-00	Outlet	4106	884	NO DATA
08-14-00	Beach	41	10	NO DATA
08-14-00	Parking lot	20	10	NO DATA

Appendix 15. Bacteriological Analyses
San Mateo County Health Department

DATE	SITE	TOTAL COLIFORMS	FECAL COLIFORMS	<i>Escherichia Coli</i>
		per 100 ml	per 100 ml	per 100 ml
10-16-00	Oddstad	700	80	80
10-16-00	North Fork	790	170	130
10-16-00	Linda Mar	790	130	130
10-16-00	Peralta	1700	790	790
10-16-00	Outlet	1100	460	330
10-16-00	Beach	330	20	20
10-16-00	Parking lot	20	less than 20	less than 20
10-23-00	Oddstad	230	20	20
10-23-00	North Fork	700	170	170
10-23-00	Linda Mar	790	130	80
10-23-00	Peralta	16000	9200	3500
10-23-00	Outlet	1300	330	330
10-23-00	Beach	230	20	20
10-23-00	Parking lot	80	20	20
10-30-00	Oddstad	330	230	230
10-30-00	North Fork	16000	9200	5400
10-30-00	Linda Mar	9200	5400	5400
10-30-00	Peralta	9200	5400	2400
10-30-00	Outlet	5400	2400	2400
10-30-00	Beach	1300	490	490
10-30-00	Parking lot	130	50	50
11-06-00	Oddstad	490	50	50
11-06-00	North Fork	790	170	130
11-06-00	Linda Mar	700	80	80
11-06-00	Peralta	490	140	140
11-06-00	Outlet	790	330	230
11-06-00	Beach	330	130	130
11-06-00	Parking lot	700	50	50
11-13-00	Oddstad	490	20	20
11-13-00	North Fork	1300	140	110
11-13-00	Linda Mar	1300	130	130
11-13-00	Peralta	1400	230	230
11-13-00	Outlet	1100	230	130
11-13-00	Beach	490	50	50
11-13-00	Parking lot	20	20	20

